TRANSACTIONS

of the

American Fisheries Society

"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

FIFTY-FIRST ANNUAL MEETING

Allentown, Pennsylvania

SEPTEMBER 5, 6, 7, 1921

Volume LI

1921 - 1922

Edited by Ward T. Bower

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Science Lib
Direct

The American Fisheries Society

Organized 1870 Incorporated 1910

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Presidents, Terms of Service and Places of Meeting.

The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for the period shown opposite their names, but they presided at the subsequent meeting.

1. WILLIAM CLIFT..............1870–1872....New York, N. Y.
2. WILLIAM CLIFT..............1872–1873....Albany, N. Y.
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5. ROBERT B. ROOSEVELT........1875–1876....New York, N. Y.
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13. JAMES BENKARD.............1883–1884....New York, N. Y.
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15. MARSHALL MCDONALD........1885–1886....Washington, D. C.
16. W. M. HUDSON..............1886–1887....Chicago, Ill.
17. WILLIAM L. MAY............1887–1888....Washington, D. C.
18. JOHN H. BISSELL............1888–1889....Detroit, Mich.
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20. EUGENE G. BLACKFORD.......1890–1891....Put-in Bay, Ohio
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24. WILLIAM L. MAY............1894–1895....Philadelphia, Pa.
25. L. D. HUNTINGTON..........1895–1896....New York, N. Y.
26. HERSCHEL WHITAKER.......1896–1897....New York, N. Y.
27. WILLIAM L. MAY............1897–1898....Detroit, Mich.
28. GEORGE F. PEABODY..........1898–1899....Omaha, Neb.
29. JOHN W. TITCOMB...........1899–1900....Niagara Falls, N. Y.
30. F. B. DICKERSON............1900–1901....Woods Hole, Mass.
31. E. E. BRYANT...............1901–1902....Milwaukee, Wis.
32. GEORGE M. BOWERS..........1902–1903....Put-in Bay, Ohio
33. FRANK N. CLARK............1903–1904....Woods Hole, Mass.
34. HENRY T. ROOT.............1904–1905....Atlantic City, N. J.
35. C. D. JOSLYN...............1905–1906....White Sulphur Spgs, W.Va.
36. E. A. BIRGE.................1906–1907....Grand Rapids, Mich.
37. HUGH M. SMITH.............1907–1908....Erie, Pa.
38. TARLETON H. BEAN...........1908–1909....Washington, D. C.
39. SEYMOUR BOWER............1909–1910....Toledo, Ohio
40. WILLIAM E. MEEHAN........1910–1911....New York, N. Y.
41. S. F. FULLERTON............1911–1912....St. Louis, Mo.
42. CHARLES H. TOWNSEND......1912–1913....Denver, Colo.
43. HENRY B. WARD............1913–1914....Boston, Mass.
44. DANIEL B. FEARING.........1914–1915....Washington, D. C.
45. JACOB REIGHARD.............1915–1916....San Francisco, Calif.
46. GEO. W. FIELD..............1916–1917....New Orleans, La.
47. HENRY O'MALLEY...........1917–1918....St. Paul, Minn.
48. M. L. ALEXANDER............1918–1919....New York, N. Y.
49. CARLOS AVERY..............1919–1920....Louisville, Ky.
50. NATHAN R. BULLER.........1920–1921....Ottawa, Canada
51. WILLIAM E. BARBER.........1921–1922....Allentown, Pa.

*A special meeting was held at the Centennial Grounds, Philadelphia, Pa., October 6 and 7, 1876.

American Fisheries Society

ORGANIZED 1870

CERTIFICATE OF INCORPORATION.

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the Acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the Society is the AMERICAN FISHERIES SOCIETY.
2. That the term for which it is organized is nine hundred and ninety-nine years.
3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(*a*) To acquire, hold and convey real estate and other property, and to establish general and special funds.
(*b*) To hold meetings.
(*c*) To publish and distribute documents.
(*d*) To conduct lectures.
(*e*) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.
(*f*) To acquire and maintain a library.
(*g*) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

SEYMOUR BOWER (Seal)
THEODORE GILL (Seal)
WILLIAM E. MEEHAN (Seal)
THEODORE S. PALMER (Seal)
BERTRAND H. ROBERTS (Seal)
HUGH M. SMITH (Seal)
RICHARD SYLVESTER (Seal)

Recorded April 16, 1911.

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PART I

BUSINESS SESSIONS

PROCEEDINGS

of the

AMERICAN FISHERIES SOCIETY

FIFTY-FIRST ANNUAL MEETING AT ALLENTOWN, PENNSYLVANIA

SEPTEMBER 5, 6, 7, 1921

The Fifty-first Annual Meeting of the American Fisheries Society was held at the Hotel Traylor, Allentown, Pennsylvania, on September 5, 6, 7, 1921.

Opening Session, Monday Morning, September 5, 1921.

The meeting was called to order by President Nathan R. Buller of Harrisburg, Pa., at 10:30 o'clock a. m.

The Hon. Malcolm W. Gross, Mayor of the City of Allentown, delivered a cordial address of welcome.

The President called upon Mr. Carlos Avery of St. Paul, Minn., former president of the Society, who made an appropriate response.

REGISTERED ATTENDANCE.

The registered attendance was 45, as follows:

W. E. ALBERT, Des Moines, Iowa.
M. L. ALEXANDER, New Orleans, La.
CARLOS AVERY, St. Paul, Minn.
W. E. BARBER, LaCrosse, Wis.
W. G. BELL, Baltimore, Md.
DR. DAVID L. BELDING, Hingham, Mass.
J. R. BERKHOUS, Torresdale, Pa.
BERKS COUNTY ROD & GUN ASSOCIATION, Reading, Pa.
WARD T. BOWER, Washington, D. C.
ERNEST CLIVE BROWN, New York, N. Y.
E. T. D. CHAMBERS, Quebec, Canada.
OSWILL CHAPMAN, De Bruce, N. Y.
ALVA CLAPP, Pratt, Kan.
E. W. COBB, St. Paul, Minn.
JOHN M. CRAMPTON, New Haven, Conn.
L. H. DARWIN, Seattle, Wash.
DR. GEORGE C. EMBODY, Ithaca, N. Y.
WALTER G. EMERICH, Watervliet, N. Y.
HARRY A. GRAMMES, Allentown, Pa.
JOHN HAMBERGER, Erie, Pa.
JOE H. HART, Allentown, Pa.
S. B. HAWKS, Bennington, Vt.
CHAS. O. HAYFORD, Hackettstown, N. J.
MRS. CHAS. O. HAYFORD, Hackettstown, N. J.
CARL KRAIKER, Philadelphia, Pa.
GLEN C. LEACH, Washington, D. C.
E. LEE LECOMPTE, Baltimore, Md.

Wm. S. Leeser, Reading, Pa.
Honore Mercier, Quebec, Canada.
Arthur Merrill, Sutton, Mass.
Elmer Merrill, Sutton, Mass.
Arthur L. Millett, Boston, Mass.
Paradise Brook Trout Co., Henryville, Pa.
Edward E. Prince, Ottawa, Canada.
Wm. H. Rowe, West Buxton, Me.
H. R. Stackhouse, Harrisburg, Pa.
M. G. Sellers, Philadelphia, Pa.
L. S. Spragle, Henryville, Pa.
John W. Titcomb, Albany, N. Y.
Frederick Tresselt, Hackettstown, N. J.
Gen. Harry C. Trexler, Allentown, Pa.
John H. Wallace, Jr., Montgomery, Ala.
Robertson S. Ward, East Orange, N. J.
B. O. Webster, Madison, Wis.
John P. Woods, St. Louis, Mo.

New Members.

In the year ensuing since the last annual meeting the following 132 new members have been elected:

Abrams, Milton, 560 Brook Ave., New York, N. Y.
Adcock, A. Y., 5929 Wayne Ave., Chicago, Ill.
Albert, W. E., State Fish and Game Warden, Des Moines, Iowa.
Armstrong, Ronald Kennedy, Dalton House, Dalton, Northumberland, England.
Atlantic Biological Station, St. Andrews, New Brunswick, Canada.
Bazeley, Hon. Wm. A. L., Commissioner of Conservation, Room 519, State House, Boston, Mass.
Bell, Wm. G., 512 Munsey Bldg., Baltimore, Md.
Bennett, L. H., Bureau of Fisheries, Washington, D. C.
Bernier, Dr. J. E., No. 5 D'Auteuil St., Quebec, Canada.
Bonner, Albert E., Coopersville, Mich.
Bothwell, David, Anderson Lake Hatchery, Kildonan, British Columbia.
Breder, C. M., Jr., 23 Humboldt St., Newark, N. J.
Buller, C. R., Pleasant Mount, Wayne Co., Pa.
Buschmann, L. C., Franklin Packing Co., L. C. Smith Bldg., Seattle, Wash.
Cassell, John S., 4100 Springdale Ave., Baltimore, Md.
Clapp, Alva, State Game and Fish Warden, Pratt, Kans.
Clemens, Wilbert A., Dept. of Biology, University of Toronto, Toronto, Canada.
CLUBS:
- Akron Game and Fish Association, Akron, Pa.
- Ashland Fish and Game Protective Ass'n, Ashland, Pa.
- Bair Camp, Charles H. Foster, Sec., 221 Linden St., Scranton, Pa.
- Bemidji Trout Club, R. H. Schumaker, Sec.-Treas., Bemidji, Minn.
- Berks County Rod & Gun Ass'n, W. E. Wounderly, Sec., 615 Eisenbrown St., Reading, Pa.
- Bethlehem Game, Fish and Forestry Ass'n, 423 Brodhead Ave., Bethlehem, Pa.
- Birdsboro Fish and Game Ass'n, Elmer E. Squibb, Sec., Birdsboro, Pa.
- Blandburg Camp No. 115, United Sportsmen of Pennsylvania, Blandburg, Pa.
- Bowmanstown Rod and Gun Club, Wm. A. Yale, Sec., Bowmanstown, Pa.
- Chicora Outing Club, R. J. Gainford, Pres., Chicora, Pa.
- Club Denarius, 8 Susquehanna St., Barnesboro, Pa.

CUMBERLAND CO. FISH AND GAME ASS'N, Geo. E. Orr, Sec., Portland, Me.
FAIRBROOK COUNTRY CLUB, C. O. Miller, Sec., Tyrone, Pa.
FERGUS FISHING AND GAME CLUB, J. C. Henkes, Sec., Fergus Falls, Minn.
JEFFERSON CO. GAME AND FISH ASS'N, Brookville, Pa.
LOWELL FISH AND GAME ASS'N, Willis S. Holt, Sec., Box 948, Lowell, Mass.
MONTGOMERY CO. FISH, GAME & FORESTRY ASS'N, H. G. Unger, Sec., 820 West Marshall St., Norristown, Pa.
MOUNT PLEASANT HUNTING & FISHING ASS'N, Mount Pleasant, Pa.
NAZARETH ROD AND GUN CLUB, INC., Nazareth, Pa.
NEW JERSEY FISH & GAME CONSERVATION LEAGUE, Arthur J. Neu, Treas., 31 Clinton St., Newark, N. J.
NORTH CHAUTAUQUA FISH AND GAME CLUB, Dunkirk, N. Y.
PARK RAPIDS COMMUNITY CLUB, G. H. Friend, Treas., Park Rapids, Minn.
PENNSYLVANIA STATE FISH AND GAME PROTECTIVE ASS'N, City Club, 313 South Broad St., Philadelphia, Pa.
PLYMOUTH CAMP No. 136, UNITED SPORTSMEN OF PENNSYLVANIA, H. A. Ledden, Sec., 53 Oxford St., Lee Park, Wilkes Barre, Pa.
PORTER'S LAKE HUNTING AND FISHING CLUB, Otto C. Feil, Sec., 2207 North Sixth St., Philadelphia, Pa.
RAMSEY CO. UNITED SPORTSMEN'S ASS'N, J. McCarthy, Sec., 636 Grand Ave., St. Paul, Minn.
RIDGWAY BRANCH, WILD LIFE LEAGUE, Earl E. Gardner, Sec., Ridgway, Pa.
RINGGOLD ROD AND GUN CLUB, Pen Argyl, Pa.
ROD AND GUN PROTECTIVE ASS'N, East Greenville, Montgomery Co., Pa.
SANCON VALLEY CAMP No. 168, UNITED SPORTSMEN OF PENNSYLVANIA, Hellertown, Pa.
SAW CREEK HUNTING AND FISHING ASS'N, M. S. Kister, Treas., East Stroudsburg, Pa.
SPORTSMEN'S CLUB OF DULUTH, 403 Wolvin Bldg., Duluth, Minn.
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WEST PHILADELPHIA ROD AND GUN CLUB, Wm. L. Bryan, Sec., 55th and Springfield Ave., Philadelphia, Pa.
WILD LIFE LEAGUE, Sheffield Branch, G. McKillip, Treas., Sheffield, Pa.
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WINDSOR CO. FISH AND GAME CLUB, C. W. Grinnel, Sec., Norwich, Vt.

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CORSON, ALAN, City Hall, Philadelphia, Pa.
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FLEMING, JOHN H., Columbia City, Ind.
FOSTER, WM. T., 707 Coleman St., Easton, Pa.
GANTENBEIN, D., Diamond Bluff, Wis.
GERDUN, C., 505 Commercial Bank Bldg., Cleveland, Ohio.
GOODHUE, E. C., Sherbrooke, Quebec.
GREEN, JOHN W., Carlton, Minn.

HAMBERGER, HON. JOHN, 16 East 8th St., Erie, Pa.
HARRISON, C. W., 801 Rogers Bldg., Dominion Government Fisheries Office, Vancouver, British Columbia.
HEATHLEY, GEORGE, Middleton, Annapolis Co., Nova Scotia.
HEUCHELE, G. L., Bureau of Fisheries, Put-in Bay, Ohio.
HOOFNAGLE, G. W., Bureau of Fisheries, Orangeburg, S. C.
HUBBS, CARL L., Museum of Zoology, University of Michigan, Ann Arbor, Mich.
INNIS, WM., Northeast cornor 12th and Cherry Sts., Philadelphia, Pa.
JONES, CHAPIN, State Forester, University of Virginia, Charlottesville, Va.
LEBOUR, DR. MARIE V., Marine Laboratory, Citadel Hill, Plymouth, England.
LEESER, WM. S., 919 Walnut St., Reading, Pa.
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UNIVERSITY OF INDIANA, Bloomington, Ind.
UNIVERSITY OF MICHIGAN, Ann Arbor, Mich.
UNIVERSITY OF NEBRASKA, Lincoln, Neb.
UNIVERSITY OF TORONTO, Toronto, Canada.
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LOWELL, RALPH P., Sanford, Me.
MANSFIELD, HARRY C., Russells Point, Ohio.
MAPES, WM. C., Fort On Appelle, Saskatchewan.
MATTHEWS, J. H., Research and Information Dept., No. 1 Fulton Fish Market, New York, N. Y.
McLEAN, MARSHALL, 27 Cedar St., New York, N. Y.
MITCHELL, EDW. W., Livingston Manor, Sullivan Co., New York.
MONEY, GEN. NOEL, Qualicum Beach, British Columbia.
MOTHERWELL, MAJOR J. A., Chief Inspector of Fisheries, Rogers Bldg., Vancouver, British Columbia.
NORGORE, MARTIN, 1908 N. 36th St., Seattle, Wash.
OAKES, JOSEPH, Box 5, Belleville, Ontario.
ODELL, CLINTON M., 1815 Fremont Ave., South, Minneapolis, Minn.
PARADISE BROOK TROUT CO., Henryville, Pa.
PHILLIPS, JOHN M., Vice-Pres., Board of Game Commissioners, 2227 Jane St., South Side, Pittsburgh, Pa.
REA, KENNETH G., 285 Beaver Hall Hill, Montreal, Canada.
REFORD, ROBERT WILSON, 300 Drummond St., Montreal, Canada.
REID, HUGH J., Winnipegoses, Manitoba, Canada.
RILEY, HON. MATTHEW, 304 Jefferson Ave., Ellwood City, Pa.
RODD, R. T., Banff, Alberta.
RUHE, E. LEHMAN, 24 S. 13th St., Allentown, Pa.
SCOTT, THOMAS E., Fisheries Overseer, Hope, British Columbia.
SCOVILLE, R. L., 50 Church St., New York, N. Y.
SHELDON, H. P., Fish and Game Commissioner, Montpelier, Vt.
SMITH, WALTER S., Game Warden, 114 North Jefferson St., Staunton, Va.
SNOWDEN, ALEX'R O., JR., 1058 Main St., Peekskill, N. Y.
SPENCER, H. B., Room 1223 Munsey Bldg., Washington, D. C.
STACKHOUSE, H. R., Department of Fisheries, Harrisburg, Pa.
STATE FISHERY ORGANIZATIONS:
Indiana, Department of Conservation, Division of Fisheries and Game, Indianapolis, Ind.
Iowa, Fish and Game Department, Des Moines, Iowa.
Louisiana, Department of Conservation, New Orleans, La.
Massachusetts, Department of Conservation, Boston, Mass.
Minnesota, Fish and Game Commission, St. Paul, Minn.
Ohio, Bureau of Fish and Game, Columbus, Ohio.
Oregon, Fish Commission of Oregon, 1105 Gasco Bldg., Portland, Oreg.

STOKKE, G. B., 16 Exchange Place, New York, N. Y.
TAIT, THORFIN, 64 Hillside Ave., Metuchen, N. J.
TRESSELT, FREDERICK, State Fish Hatchery, Hackettstown, N. J.
TRESSLER, DR. DONALD K., Mellon Institute, Pittsburgh, Pa.
TRUITT, R. V., University of Maryland, College Park, Md.
WEBSTER, B. O., Commissioner of Fisheries, Madison, Wis.
WHITE, DR. E. HAMILTON, 298 Stanley St., Montreal, Canada.
WOLF, CHARLES F., Birchwood, Wis.

LIST OF CONTRIBUTORS TO MEET DEFICIENCY

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T. S. Palmer	2.00
A. S. Pearse	2.00
P. G. Zalsman	1.50
Emmeline Moore	1.00
Number of contributors	70
Amount contributed[1]	$616.41

[1] Includes contributions of $139 received after the Treasurer's books were closed, as stated in his report, page 17. These are indicated above by an asterisk.

REPORT OF THE EXECUTIVE SECRETARY.

Washington, D. C., September 3, 1921.

TO THE OFFICERS AND MEMBERS OF THE AMERICAN FISHERIES SOCIETY:

In addition to conducting the increasingly heavy correspondence and attending to general administrative matters of the Society, the editing

and preparation of the Fifieth Anniversary volume of the Transactions has constituted a very important feature of the work of the Executive Secretary. Preliminary to this undertaking much careful consideration was given to the desirability of resuming the practice in effect prior to 1914 of publishing the Transactions in one volume instead of quarterly issues. One volume seemed desirable both upon the grounds of economy and convenience. Investigation showed that it could be issued cheaper than the quarterlies, notwithstanding its inadmissibility at the low second class mail rate. Also it appeared that there was dissatisfaction with the quarterlies because of the greater chance of their becoming misplaced and causing incomplete sets. So with the approval of officers of the Society one volume was decided upon. This course has met with hearty endorsement.

Bids were solicited for printing, and the offer of the W. F. Roberts Company, Washington, D. C., was accepted, this firm's quotation of $3.45 per page plus certain extras being lowest. The volume aggregates 446 pages and contains the business proceedings and 34 papers. With the exception of the slightly larger 1910 issue, this volume is much larger than any other. The total cost of printing the edition of 750 copies was $1,991.15, or about $2.65 per copy. It was decided to sell copies for $3.00 each, postage included.

All of the back numbers of the Transactions are now in the custody of the Executive Secretary. Since the last meeting those in the possession of Dr. C. H. Townsend, former corresponding secretary, and Dr. Raymond C. Osburn, former executive secretary, have been received. There are approximately 3,300 copies on hand, including the quarterlies for the six years of their publication. Back numbers for 25 years are available for sale. This is not for the last 25 years, as there are no copies for 1899, 1903, and 1905. Since the last meeting, Transactions to the value of about $200 have been sold.

At the last annual meeting the Treasurer pointed out the urgent need of increased revenue, and showed that the Society could not, as things were going, continue to meet its obligations without increasing the dues or taking other appropriate action. While his report indicated an apparent balance of about $260 on the right side of the ledger, as a matter of fact the Society was then in a state of deficiency as bills for printing the previous year's Transactions had not been paid. All of this was known when the Fiftieth Anniversary volume was issued, but as was pointed out by certain members of the Society, the printed Transactions constitute the permanent record of real work and reflect the Society's standing and importance, therefore they did not deem it expedient to curtail or delay the issuance of a volume in keeping with the objects and purposes of the organization. Publication of the Anniversary number of the Transactions was accordingly undertaken in the knowledge that a deficit would be created. Inasmuch as practically the entire current fund was absorbed in the payment of back bills and running expenses other than printing the Fiftieth Anniversary volume, it was decided, with the approval of officers of the Society, to borrow about $2,000 from the Permanent Fund to pay for this volume, with the distinct understanding that the Fund would be reimbursed, with interest at 4 per cent per annum. The Permanent Fund has been drawing interest at 4 per cent, and as reimbursement is to be

made as rapidly as possible at the same rate of interest, this fund ultimately will be in no wise impaired.

Earnest effort has been constantly made to raise funds during the year. Numerous letters have been written to effect sales of Transactions and to secure new members, and some success has resulted. Also a circular was addressed to the members on June 20, 1921, soliciting contributions. Another circular was mailed directing attention to the prize contest.

It is suggested that for at least a year or two the annual dues for regular members be increased from $2.00 to $3.00; of state commissions from $10.00 to $25.00; and life members from $25.00 to $50.00. Also dues of fish and game clubs and of dealers might be increased from $5.00 to $10.00. One of our enthusiastic members, Dr. W. P. Manton, of Detroit, suggests an increase in dues to $5.00 or even $10.00, and that there be a difference in the membership created, those who prefer to pay $5.00 to be designated as Members, and those paying $10.00 designated Fellows, privileges being the same in either class. This is a valuable and timely suggestion.

The present membership of the Society is as follows: Honorary, 66; corresponding, 11; patrons, 53; active, 502; total, 632.

WARD T. BOWER,
Executive Secretary.

The report of the Executive Secretary was adopted.

REPORT OF THE TREASURER.

Boston, Mass., September 3, 1921.

TO THE AMERICAN FISHERIES SOCIETY:

Herewith is my annual report as Treasurer from the meeting in September, 1920, to August 10, 1921.

This report presents the anomaly of an organization which, if it is to be square with the outside world, must go in debt to itself. The immediate cause is that this year bills have come in for printing the Transactions for two years; that for the 1920 meeting at Ottawa was presented promptly on publication of the volume, while the bill for the 1919 meeting at Louisville did not come in until June of this year. A further cause is that the 1920 volume was much larger than any report in recent years and costs of printing were unusually high.

If these two bills, as well as bills for running expenses, were to be paid, as they naturally should be, it would leave the treasury more than bankrupt. In order to pay the bill the Treasurer, with the advice and consent of the President and Executive Secretary and other officials, decided that the only avenue open was to draw temporarily upon the Permanent Fund. This was done. Such action was not supported by the Constitution, but it was felt that good judgment was used and that the action would have your hearty endorsement. It is proposed to reimburse the Permanent Fund with interest, so that eventually the fund will once more be intact.

Some comment may be made upon the apparently large bill for printing the Transactions of the Fiftieth Anniversary Meeting at Ottawa, Canada, but I am confident that consideration of the articles therein con-

tained, their great number, and their unusual scientific and practical value, will convince any member that the money was well spent, however embarrassing it may have been to meet the bill. Personally, I believe that the Society can take great credit for such a volume, also that the Executive Secretary has cause to be congratulated upon its production.

When it was first proposed to pay these bills in the manner above stated, action was at once taken to replenish the treasury. Letters were written to delinquents and appeals made to all members to pay their dues promptly, and as a result the condition of the Society as far as the collection of dues is concerned is perhaps better than for many years. In addition, your President issued an appeal on June 20th, for contributions to put our finances on a sound basis. The amount received to August 10, 1921, from 53 contributors totals $487.41, with more to be heard from.

Despite the increased cost of all necessary materials and printing, the dues of the Society have remained at the almost negligible amount of $2.00 a year. It cost $1,991.15 to publish the Transactions for the Ottawa meeting, or considerably more per volume than the $2.00 paid by each member. On August 10th we had only 491 active members which, if everyone paid, would provide but $982.00.

This meeting should take some steps to provide increased revenue; this is necessary if the Society is to pay its bills. A vigorous campaign for new members, especially state and club memberships, if intensively conducted, would add considerably to the yearly revenue. If something is not done, it seems necessary to increase the dues or discontinue the Transactions. The latter is unthinkable, for it would practically mean the living death of the Society. My personal view is that whatever the success or failure of a membership campaign, under no circumstances should the cost of printing the Transactions be in excess of a sufficient balance for ordinary running expenses. In other words, I do not believe that we should allow ourselves again to run heavily into debt.

The raising of the dues in an appreciable amount would, in my opinion, reduce the membership to such an extent that there would be little, if any, financial gain over the present two-dollar-a-year policy. But I feel that the matter of increasing dues is one that should come before this meeting in the form of a resolution or order, and have definite action.

Following is a tabulation of receipts and disbursements:

Receipts

Balance in Treasury after the meeting of 1920		$264.51
Annual dues:		
For the year 1916	$ 2.00	
" " " 1917	6.00	
" " " 1918	36.00	
" " " 1919	54.00	
" " " 1920	780.00	
" " " 1921	50.00	
" " " 1922	4.00	
		932.00
Club memberships		10.00
State memberships		20.00

Life membership	25.00	
Donations	[1]487.41	
Sale of Transactions	226.37	
Refund on reprints	18.00	
Interest	3.41	
Collection and exchange	.70	
Refunds and adjustments	4.00	
Refund, from the Permanent Fund, of life memberships deposited therein by error	75.00	
		$2,066.40

Disbursements.

Reporting 1920 meeting	$207.40	
Literature for meetings, stationery, etc.	138.21	
Printing Transactions, 1919	714.31	
Postage	133.36	
Exchange	3.22	
Express	41.70	
Services to Treasurer	100.00	
Entries to adjust bank account (protested checks)	2.00	
		1,340.20
Balance, per cash book		$ 726.20

Permanent Fund.

Balance as reported at 1920 meeting		$3,111.99
Interest		183.00
		$3,294.99
Disbursement for prize paper, Dr. Wm. C. Kendall	$100.00	
Withdrawal of funds deposited in the permanent fund through misunderstanding	75.00	
Temporary loan for payment of bill for printing Transactions of 1920, Vol. 50 (withdrawn, but not yet handed to the W. F. Roberts Co., Inc., for whom it is intended)	1,991.15	
		2,166.15
Balance		$1,128.84

Respectfully submitted,

ARTHUR L. MILLETT,
Treasurer.

The report of the Treasurer was referred to the Auditing Committee.

MR. TITCOMB: Now that we are back on the right basis in issuing one volume and in more fully publishing the discussion, which oftentimes brings out more information than the original paper, a member who does not attend the meetings will be able to glean from

[1] Included $10 which was later withdrawn to apply on a life membership.

the reports the information which he needs. He can well afford to be a member of the Society, whether or not he can attend the meetings. Many have not joined because they could not be in attendance. I move that the dues be increased to $3.00 a year, and that every one make an effort to get a new member. I also suggest the preparation of a circular to be used in a campaign to secure new members, particularly states and clubs.

Mr. Avery: At the Louisville meeting I moved to increase the dues and was voted down on the ground that many of the members have small incomes, and that we would lose if we raised the dues. The same condition prevails now. I am not opposed to raising the dues, because I feel that the Transactions are well worth the added fee, but what we want is as large a membership as may be possible in order to expand the Society's usefulness. If we increase the dues, we may reduce the membership unless there is a very aggressive membership campaign. This matter ought to be referred to a special committee, which would make a definite report without delay.

Mr. Millett: I believe in Mr. Avery's idea of a special committee to report not later than tomorrow. I move that such a committee of five be appointed.

Mr. Titcomb withdrew his motion, and Mr. Millett's motion was duly carried.

Mr. Buller: The suggestion of Mr. Titcomb to secure new members to put the Society on a sound financial basis interests me greatly. I will mail at my own expense a circular of that kind to at least 300 anglers' clubs in Pennsylvania. I feel sure that many will be glad to join.

Mr. Alexander: The American Fisheries Society occupies a most important position in the United States; it must continue its meetings and have its scientific papers to show what is necessary in sustaining the great fishing industry of this country. What is a paltry $2,000 to an organization that has a membership of five hundred? I will guarantee to take into membership all clubs in Louisiana. I do not know how many there are, but if 10, I will guarantee to get the 10; if 50 I will guarantee the 50. And if it needs an individual subscription, I will be glad to make it. I think that we should contribute towards the liquidation of this obligation, either in actual money subscribed personally, or in efforts to get additional supporters and membership.

APPOINTMENT OF COMMITTEES

During the several sessions, the President appointed the following regular committees:

Resolutions: J. P. Woods, E. T. D. Chambers, W. E. Albert, G. C. Leach, M. G. Sellers.

Time and place of meeting: Carlos Avery, E. E. Prince, Chas. O. Hayford.

Nominations: E. W. Cobb, W. H. Rowe, A. L. Millett, R. S. Ward, B. O. Webster.

Auditing: G. C. Leach, J. W. Titcomb, W. E. Barber.

The following special committees were also appointed:

Committee on Financial Condition of the Society: Carlos Avery, J. W. Titcomb, G. C. Leach, A. L. Millett, Ward T. Bower.

Committee to Secure New Members during the Ensuing Year: J. W. Titcomb, Carlos Avery, M. L. Alexander, A. L. Millett, Ward T. Bower.

Committee to Consider the matter of Affiliation of the National Association of Fisheries Commissioners with the American Fisheries Society: G. C. Leach, Harry A. Grammes, Carlos Avery, J. W. Titcomb.

Owing to the absence of certain members of the Committee on Awards, President Buller named E. W. Cobb, Chas. O. Hayford, and G. C. Embody to serve with the Chairman, Mr. Titcomb.

REPORT OF COMMITTEES ON RELATIONS WITH NATIONAL AND STATE GOVERNMENTS

Mr. E. W. Cobb, Chairman of the Committee on Relations with National and State Governments, presented a report from which the following is quoted:

The scope of the committee's work was made to include the relations of the National and State Governments with the Committee, with each other, and with individuals and groups actively engaged in fishery matters.

An offer was made to bring before the Society any matter of interest for any one not able to be present at the meeting. The replies were not numerous, and definite recommendations were few and far between. Among the answers was one from Dr. C. W. Greene, University of Missouri, Columbia, Mo., who suggested the need of fishery schools where not only biological but also practical commercial fishery problems would receive consideration.

The following communication from the Fishing Gazette suggesting the need of uniform fishery statistics merits consideration:

"A comprehensive survey of the fishing industry of the United States would be greatly simplified and results obtained through planting fish fry in streams and enforcing certain closed seasons would be ascertained with ease if each State used the same form in keeping fishery statistics and collected them every year. To secure totals or comparative figures on fisheries in interstate waters under present conditions by reference to state reports, is seldom possible because no two secure the same figures in the same way. Federal statistics for given areas are

collected every five years, while some states make surveys in four, three, two or one year periods, some of these being for the fiscal year and others for the calendar year. General statistics of any value cannot be compiled from such sources, as there is no indication whether the particular year in which they are taken is an off year, year of large production, or of average yield. Universal forms for compiling statistics should be drafted with great care, and a conference on the subject should be called in each geographical district; plans should be made and an effort put forth to have the program adopted by the legislature of each state. By taking the lead in such a movement the American Fisheries Society could wield valuable influence and perform a valuable service to those engaged in the fishery."

Letters were forwarded to various clubs throughout Minnesota, asking for opinions on federal control of the fisheries, as this seemed to be a matter of cooperation. The replies showed that the subject had not been considered to any extent and that ideas in regard to it were very indefinite. It would seem, however, that many persons saw the need of uniform control of interstate waters, with a strong feeling that the regulations should correspond very closely to those existing in Minnesota. Nowhere in the replies was there any sentiment in favor of this control extending to waters other than those of the boundary.

The report was duly adopted.

The session adjourned.

Afternoon Session, September 5, 1920

The meeting was called to order by President Buller.

The Secretary read the following telegram of September 3, 1921, from Mr. Gardner Poole, President of the United States Fisheries Association, Boston, Mass.:

The U. S. Fisheries Association extends to you its hearty congratulations on this occasion of your fifty-first annual meeting and extends to the members of your Society a cordial invitation to attend and participate in the annual meeting and convention to be held at the Breakers Hotel, Atlantic City, New Jersey, September sixteenth and seventeenth. We are keenly desirous of having all those not commercially engaged in the industry but interested in it, become better acquainted with the commercial matters. It is felt that time and effort devoted to bringing about a better understanding between these two classes will be time well spent and will result in bringing about complete harmony of all interests. Believe that an open statement of views and a discussion between all interests will result in a common viewpoint. Our program has been arranged accordingly. The U. S. Commissioner of Fisheries and other members of the Department have been invited and many fish commissioners and other interested men not commercially engaged in the industry will be present, and I respectfully request that your Society arrange to have one or more delegates present. It is our feeling that cooperation of all those interested in the fisheries is necessary in order that the fisheries may be properly utilized to the advantage of the country.

MR. MILLETT: This is the first time we have ever received an invitation to participate in the deliberations of a practical fisheries

body. These people whom I know, as I am a member of that organization of 800 men, represent many of the fisheries concerns of this country. It seems to me that such an invitation should not be left unanswered. From an intimate knowledge of the aims and objects of the United States Fisheries Association, I want to say that there is nothing to indicate in any way that it is trying to controvert or upset any of the ideas of the American Fisheries Society. On the other hand its members are only too willing to cooperate with us. It would be a fine thing if somebody represented us in the meeting of that organization. The closer relations we establish the stronger we are making our own organization.

Dr. Prince and Mr. Leach expressed approval of the suggestions made by Mr. Millett. The President designated Messrs. Titcomb and Adams to formally represent the Society, and sent a telegram to Mr. Poole as follows:

The American Fisheries Society appreciates the cordial spirit of your telegram of September third inviting its formal representation at the meeting of the United States Fisheries Association at Atlantic City, September sixteenth and seventeenth. I am pleased to advise you that the American Fisheries Society today assembled in its fifty-first annual meeting unanimously accepts your kind invitation and has designated Mr. J. W. Titcomb, of Albany, N. Y., and Mr. W. C. Adams, of Boston, Mass., as its formal representatives. Other members including Messrs. A. L. Millett, M. G. Sellers and Ernest Clive Brown have signified their purpose of being in attendance. The American Fisheries Society extends its felicitations and best wishes and expresses the hope that the convention this month and all other activities of the United States Fisheries Association will be highly successful in every way.

Mr. L. F. Grammes announced that through the kind efforts of Mr. R. S. Ward, Fish Commissioner of New Jersey, there was present Mr. Fred G. Shaw, champion fly caster of England. He stated that Mr. Shaw had volunteered to give practical demonstrations of fly casting at one of the hatcheries near Allentown. On motion of Mr. Grammes, seconded by Mr. Titcomb, Mr. Shaw was unanimously invited to give such an exhibition. He graciously accepted.

REPORT OF COMMITTEE ON FINANCIAL CONDITION OF THE SOCIETY

The report of the special Committee on Financial condition of the Society as presented by Mr. Avery was as follows:

Your committee has met and canvassed the financial condition of the Society and begs leave to make the following recommendations:

1. That the recommendation of the Treasurer and Executive Secretary to borrow $2,000 from the Permanent Fund of the Society to pay current

indebtedness be approved, on condition that said sum be restored to the Permanent Fund as rapidly as possible together with interest at the rate of 4 per cent, and that the Treasurer be authorized to pay indebtedness of $1,991.15, on account of the printing of the 1920 Transactions, from this sum.

2. That all members be appealed to for contributions at this meeting to augment the voluntary contributions so far received which now amount to about $567.00.

3. That an appropriate circular or letter be prepared and printed calling attention to the advantage of sportmen's and anglers' clubs identifying themselves as club members with the Society, which circulars shall be furnished to the state commissioners and others with the urgent recommendation that all such clubs in the United States and Canada be informed as to the work of the Society in promoting fish propagation, prevention and control of pollution of waters, and restraint of illadvised and unnecessary drainage of lakes valuable for angling, and be invited to join this Society.

4. That the annual fee for dues of individuals and libraries be raised from $2.00 to $3.00.

5. That a special membership campaign committee be formed charged with the duty of inaugurating and conducting continuously throughout the year a vigorous and persistent campaign for new members in all classes.

Mr. Avery: With reference to that part of the committee's report urging club memberships, it was the idea that each commissioner especially should interest himself in getting the clubs of his state to join. The annual fee is only $5.00 for such memberships, and considering what the Society is doing for the benefit of sportsmen and anglers, all such clubs in the United States and Canada should be ready and willing to join, if it is properly brought to their attention.

The report of the committee was adopted.

In accordance with the action recommended in the report of the committee, Mr. Avery moved the necessary changes in Article II of the Constitution, fixing the annual dues of active members and libraries at $3.00 instead of $2.00. The amendment was adopted.

A paper entitled "Bacteriological Analysis of an Experimental Pack of Canned Salmon," by Reginald H. Fiedler, was read by Dr. Embody. Discussion followed.

A paper entitled "A New Method of Shipping Live Fish," by Edgar C. Fearnow, was read by Dr. Embody. Discussion ensued.

Dr. G. C. Embody presented a paper entitled "The Use of Certain Milk Wastes in the Propagation of Natural Fish Food." Discussion followed.

A paper entitled "Fresh Water Crustacea as Food for Young

Fishes," by Dr. William Converse Kendall, was read by Mr. Bower. Discussion followed.

Evening Session, September 5, 1921

President Buller called the meeting to order.

A paper entitled "The Domestication of Landlocked Salmon Breeders," by W. M. Keil, was read by Mr. Titcomb. Discussion followed.

Dr. G. C. Embody presented a paper entitled "Concerning High Water Temperatures and Trout." Discussion followed.

The session adjourned at 11 p. m.

Morning Session, September 6, 1921

President Buller called the meeting to order.

A telegram from Dr. H. M. Smith, United States Commissioner of Fisheries, Washington, D. C., to President Buller conveyed to the Society his best wishes for a successful meeting and extended an invitation to hold the next meeting in Washington.

President Buller announced that during the year communications had been received from the Secretary of the National Association of Fisheries Commissioners regarding possible affiliation of that organization with the American Fisheries Society, this being a subject that had been before the Society for several years but without definite action. Mr. Alexander expressed the opinion that the proposed merger would be to the advantage of the Society. Mr. Leach concurred. The President appointed Messrs. Leach, Grammes, Avery, and Titcomb a special committee to consider the matter.

Mr. Avery: When I was President of the Society I corresponded with the National Association of Fisheries Commissioners with a view to getting the organization represented at the Ottawa meeting. They promised to send a delegation there, and to undertake arrangements for affiliation at that time. They took it up at their annual meeting, but did not agree to affiliate at that time on the ground that their interests were special and they would be at a disadvantage in merging with this Society. It was explained to them, however, that our Constitution provides for sections and sectional meetings, if desired, and that their special interests could be well taken care of in such sectional organizations and meetings as well as at our annual conventions.

It seems to me that if the matter is submitted to them in that way, so that they can hold their conventions when we hold ours and carry on their sectional meeting at the same time, and therefore get what is of special interest to them, it would be beneficial to

both. They would get a larger representation at their meeting, and so would we.

Mr. Bower: Would you still have a separate organization as it exists at the present time?

Mr. Avery: It would be similar, although not identical, because our constitution recognizes this form of organization through sectional meetings. It would be practically the same, but the Association would have to relinquish its present name and the members would have to pay dues to this Society, of which it would be a section. If the Association would consent to such an organization, I think it would be highly advantageous to the American Fisheries Society.

Dr. Embody read two papers by Alexander Robertson, entitled "Further Proof of the Parent Stream Theory," and "Some Observations on the Growth of Young Sockeye Salmon." Discussion followed each paper.

A paper by Martin Norgore on "Salmon Eggs as Food for Salmon Fry," was read by Dr. Embody. Discussion followed.

Mr. J. W. Titcomb addressed the Society on "Growth of Fish and Location of Hatcheries." Discussion followed.

The session adjourned.

Afternoon Session, September 6, 1921

The meeting was called to order by President Buller.

Mr. Charles O. Hayford read a paper entitled "Some Fish-Cultural Notes, With Special Reference to Pathological Problems." Extended discussion followed.

A telegram of greeting was read from Mr. J. A. Rodd, Department of Naval Service, Ottawa, Canada.

The session adjourned.

Evening Session, September 6, 1921

The meeting was called to order by President Buller.

REPORT OF COMMITTEE ON TIME AND PLACE OF MEETING

Mr. Avery, Chairman of the Committee on Time and Place of Meeting, reported that invitations had been received for the next annual meeting from Washington, D. C., New York City, and Madison, Wis., but as most of the recent meetings had been in the east, the committee recommended that the next be at Madison. It was further recommended that the date be left to the Executive Committee.

The report was unanimously adopted.

REPORT OF AUDITING COMMITTEE

Mr. Leach reported that the Auditing Committee had examined the books of the Treasurer and found them correct.

The report was adopted, and upon motion of Mr. Alexander a vote of thanks was unanimously extended to Treasurer Millett for his efficient and faithful service.

A paper entitled "Public Aquariums," was read by Ward T. Bower. Discussion followed.

President Buller announced an open discussion on the subject "Pollution of Streams."

The session adjourned at 11 o'clock p. m.

Morning Session, September 7, 1921

President Buller called the meeting to order.

A general discussion took place on "The Effect on Fish Life of the Extended Drought and Extreme Hot Weather During the Summer of 1921."

Major C. K. Weston, of New York City, addressed the Society regarding Near East Relief. As a result, the sum of $20 was contributed and forwarded by the Executive Secretary to the Treasurer of that organization.

The following resolution was offered by Mr. Crampton:

***Resolved*, That the American Fisheries Society in meeting assembled, accepts the offer of Hon. M. G. Sellers to bring the matter of stream pollution before the American Bar Association, and expresses the hope that he will report results at the next annual meeting of the Society.**

The resolution was adopted.

Mr. Sellers: I shall endeavor to report to you. I wish to explain that the American Bar Association has as its program the construction of modern laws to cover complex situations. I think we shall give them a severe task if we can get them started on the subject of stream pollution.

President Buller introduced Mr. Joe H. Hart, of Allentown, Pa., who asked that the Society adopt the following resolution:

***Resolved*, That the American Fisheries Society, assembled at the Hotel Traylor, Allentown, Pa., on the occasion of its Fifty-First Annual Meeting on this the 7th day of September in the year of our Lord nineteen hundred and twenty-one, favor the adoption of the poem "The Star Spangled Banner" by Francis Scott Key, music by Samuel Arnold, to be our national anthem, and we further recommend and favor the petitioning of the Congress of the United States of America to enact a law declaring the Star Spangled Banner to be our National Anthem, and we further recommend that Congress make such rules and regulations as will insure the observance of the same.**

The resolution was adopted.

REPORT OF COMMITTEE ON AWARDS

Mr. Titcomb, Chairman of the Committee on Awards, submitted the following report:

The Committee has passed upon five papers under the three heads for which prizes were offered.

Under the first the prize is for the best contribution on fish culture, either new or practical fish-cultural plans or description of the methods employed in the advancement of fish-cultural work. In this class a paper was submitted by Martin Norgore, entitled "Salmon Eggs as Food for Salmon Fry," reporting on the results of experiments carried on at the University of Washington. The committee feels that this paper is to be highly commended for the grade of work being performed upon a very important problem of fish nutrition, but that it has not been pursued far enough to warrant a prize.

In the same class of fish-cultural work is the paper by E. C. Fearnow, entitled "A new Method of Shipping Live Fish," which is a discussion of experiments upon an important economic phase of fish transportation. The committee does not feel that these experiments have been carried far enough to warrant a prize.

Under the second head a prize is offered for the best contribution on biological investigations applied to fish-cultural problems. In this class are two papers by Alexander Robertson, one entitled "Further Proof of the Parent Stream Theory," and the other, "Some Observations on the Growth of Young Sockeye Salmon." Mr. Robertson has made important additions to our knowledge of the life history of the sockeye salmon. The work is of a high grade, but the investigations have not been extended over a sufficiently long period to warrant a prize for either paper.

Under the third head a prize is offered for the best contribution dealing with problems of the commercial fisheries. Your committee regrets to observe that there is only one paper on this important phase. It is entitled "Bacteriological Analysis of an Experimental Pack of Canned Salmon," by Reginald H. Fiedler. This paper deals with a very important problem of the salmon canner, and the work is highly commendable, but definite conclusions have not been proved. No prize is recommended, much as we are obliged to regret such action.

The Committee, in connection with its report, offers the recommendation that when, in its judgment, a non-competitive paper has been submitted which appears to be of unusual merit, the conditions prescribing the time limit within which such paper should have been submitted in competition may be removed and the paper may be acted upon by the Committee on Awards, the same as all competitive papers regularly submitted. This recommendation is made because the committee feels that both this year and last, at least one paper was submitted which was fully as valuable as the competitive papers, but was not submitted in competition.

The report was unanimously adopted. Also a vote of thanks was extended to the committee for its very efficient efforts.

REPORT OF THE COMMITTEE ON RESOLUTIONS

Mr. John P. Woods submitted the report of the Committee on Resolutions as follows:

WHEREAS, The problem of the abatement of the nuisance of pollution of fresh and salt waters is demanding nation-wide attention, and

WHEREAS, The Secretary of Commerce, the Honorable Herbert Hoover, has recently called into conference representatives of Atlantic and Gulf Coast States to consider this important question, resulting in the offer of Federal aid in the problem,

Therefore be it resolved, That the American Fisheries Society in convention assembled at Allentown, Pa., hereby endorses the action of the Secretary of Commerce in his efforts to aid the States to combat all forms of water pollution and to overcome its disastrous effects on fish life, and be it further

Resolved, That the American Fisheries Society does hereby pledge its cooperation and support to the Secretary of Commerce, and that a copy of this resolution be transmitted to Secretary Hoover.

WHEREAS, One of the main objects of this Society is to encourage and promote commercial fisheries, and

WHEREAS, There has possibly been some unintentional neglect in this respect by the Society,

Therefore be it resolved, That the valued treatise presented by Arthur L. Millett, of Massachusetts, at the Fiftieth Annual Meeting, entitled "Adequate Fish Inspection: A means to better fish for the consumer and to increased fish food consumption," be commended to the fish departments of other States for earnest emulation, the matter being very important and highly constructive in character.

WHEREAS, The establishment of a school of fishes and fish fundamentals is now an accomplished fact through the forethought of the University of Washington as instituted under the guidance of Dean John N. Cobb, and

WHEREAS, This Society now begins to feel the good effect of such an institution, be it

Resolved, That the American Fisheries Society in convention assembled, extends its renewed compliments to Dean Cobb and faculty with congratulations to two recent graduates of the school, namely, Messrs. Martin Norgore and Reginald H. Fiedler.

WHEREAS, The Society endeavors to consecrate itself earnestly to fish fundamentals in upholding every phase of the work, and

WHEREAS, There is justified alarm over the imminence of serious harm to natural lakes of the Great Lakes region, caused by selfish interests in attempting drainage and in lowering the level of such lakes in such manner as to injure or destroy existing breeding places, nurseries and natural habitats for the various valuable food and game fishes, be it

Resolved, That this Society enter vehement protest against this injurious action and further that it pledge itself to resist all encroachments upon the priceless heritage of the people.

WHEREAS, It is well recognized by fish culturists that the artificial propagation of both large-mouth and small-mouth bass is impractical upon the large scale practiced in the propagation of other food and game fishes, that increase of these species by reproduction under natural conditions is ordinarily more than sufficient to maintain nature's balance in waters in-

habited by these species, and that the removal of parent fish from their nests results in the loss of from 500 to 2,500 helpless fry,

Resolved, That under the intensive angling of the present day, supplemented by the many new and alluring devices cast at the quarry, the conservation of these two important game fishes is necessarily dependent upon the proper protection of the parent fish during the entire period that they are spawning and caring for their young, supplemented by due precaution to maintain in all bass waters an abundance of bass food; and it is also further recommended that, for the purpose of encouraging the propagation of the bass, as an aid to other means, the establishment of refuges or nurseries in places suitable therefor be encouraged.

Whereas, There exists an urgent, nation-wide demand for closer contact and communion with fresh and salt water fishes and with aquatic inhabitants generally, and

Whereas, There is a deplorable deficiency in public facilities which afford such valuable educational advantages through the institution of publicly-owned aquariums, be it therefore

Resolved, That the entire membership be charged with the urgency in public need of such establishments.

Whereas, It has been heretofore difficult to enlist extended publication by local newspapers of the daily proceedings of the Society's convention work, and

Whereas, This difficulty has been happily overcome in this, the Allentown, Pa., meeting by a most generous allotment of newspaper space through general realization of the great public concern in the involved questions, be it

Resolved, That more than the commonplace expression of thanks in consequence is due and hereby extended to the *Morning Call*, *Evening Item*, *Chronicle and News*, *Daily Leader*, and *Allentown Record*.

Whereas, The Entertainment Committee of Allentown has been especially zealous in its efforts to afford entertainment to members of this Society, be it

Resolved, That a vote of thanks be given to this committee for its courteous consideration.

Whereas, Diversity in general entertainment is productive of better human contentment, and

Whereas, That fact is fully realized by a representative citizen of Allentown, namely, Mr. Harry A. Grammes,

Therefore be it resolved, That a vote of thanks be extended to Mr. Grammes for his hospitable endeavors so delightfully consummated.

Whereas, The courtesies extended to the assembled members by General Harry C. Trexler touches a further chord of appreciation,

Resolved, That an acclamation of thanks be accordingly given as indicative of the gratefulness of the assembly.

Whereas, The high executive ability so very modestly displayed by the retiring President, Mr. Nathan R. Buller, of Pennsylvania, during the past year touches a responsive and overflowing chord of appreciation, be it

Resolved, Therefore, That a rising vote of thanks be extended to Mr. Buller for his very graceful and effective efforts.

WHEREAS, The efficiency of Mr. Ward T. Bower, Executive Secretary, Mr. Arthur L. Millett, Treasurer, and Mr. S. B. Hawks, Recording Secretary, is duly recognized by the members, be it

Resolved, That a vote of thanks is hereby extended to them for the incalculable value of their services throughout the past year.

The report of the committee was unanimously adopted.

REPORT OF COMMITTEE ON AFFILIATION WITH NATIONAL COMMISSIONERS

Mr. Leach, Chairman of the committee appointed to consider terms of affiliation of the National Association of Fisheries Commissioners with the American Fisheries Society, submitted the following report:

It is recommended that the Executive Secretary take up with the National Association of Fisheries Commissioners the terms upon which affiliation may be consummated with the American Fisheries Society. The following is suggested: (a) That the National Association of Fisheries Commissioners renounce their title and become members of the American Fisheries Society by payment of the annual dues of $3.00 each; (b) that the American Fisheries Society create a vice-president of National Fisheries Commissioners; and (c) that the affiliation be effective in accordance with our Constitution.

The report was unanimously adopted.

MR. TITCOMB: In this connection let me say that I was one of the vice-presidents of the North American Fish and Game Protective Association. The president died and I am now the chief officer. We have funds in a bank in Canada which so far we have been unable to secure. The members and officers of that Association have gone through the formality of a meeting and we are trying to get the money and present it to the American Fisheries Society. It amounts to $100.

REPORT OF COMMITTEE ON NOMINATIONS

Mr. E. W. Cobb submitted the report of the Committee on Nominations, as follows:

President—WILLIAM E. BARBER, LaCrosse, Wisconsin.
Vice-President—GLEN C. LEACH, Washington, D. C.
Executive Secretary—WARD T. BOWER, Washington, D. C.
Recording Secretary—S. B. HAWKS, Bennington, Vermont.
Treasurer—ARTHUR L. MILLETT, Boston, Massachusetts.
Vice-Presidents of Divisions:
Fish Culture—EBEN W. COBB, St. Paul, Minnesota.
Aquatic Biology and Physics—HENRY B. WARD, Urbana, Illinois.

Commercial Fishing—GARDNER POOLE, Boston, Massachusetts.

Angling—S. THRUSTON BALLARD, Louisville, Kentucky.

Protection and Legislation—WILLIAM C. ADAMS, Boston, Massachusetts.

Executive Committee:

GEO. C. EMBODY, Chairman, Ithaca, New York.
JOHN W. TITCOMB, Albany, New York.
EDWARD E. PRINCE, Ottawa, Canada.
W. E. ALBERT, Des Moines, Iowa.
GEORGE SHIRAS, 3d, Washington, D. C.
WILLIAM H. ROWE, West Buxton, Maine.
JOHN N. COBB, Seattle, Washington.

Committee on Foreign Relations:

HUGH M. SMITH, Chairman. Washington, D. C.
CHARLES H. TOWNSEND, New York, New York.
A. C. BAXTER, Columbus, Ohio.
JOHN P. BABCOCK, Victoria, British Columbia.
L. F. AYSON, Wellington, New Zealand.

Committee on Relations with National and State Governments:

CHARLES O. HAYFORD, Chairman, Hackettstown, New Jersey.
M. L. ALEXANDER, New Orleans, Louisiana.
NATHAN R. BULLER, Harrisburg, Pennsylvania.
CARLOS AVERY, St. Paul, Minnesota.
E. T. D. CHAMBERS, Quebec, Canada.

The Secretary was directed to cast one ballot for the Society, and the respective officers were declared elected for the year 1921-22.

MR. BULLER: Before turning the Society over to my successor, I desire to thank every member who has assisted me during the past year. I now have the pleasure of inviting my successor, Mr. Barber, to the chair.

Mr. Barber here assumed the chair amid applause.

MR. BARBER: This is indeed a surprise to me, and I should be an ingrate did I not express my appreciation of the honor. The word "honor" as used in this connection by me carries with it its strongest meaning because it is a distinct honor to be President of an organization whose activities are devoted to the causes for which you are all laboring.

The word "conservation" is a comparatively new word in America. It has only been within the last fifteen years that the word has come into frequent use. But it is not a new word across the seas. In those old countries long years of inhabitancy have made it necessary for them to practice conservation of their natural resources. Had they not practiced conservation in those old countries it is doubtful that the great war would have ended yet. Mr. Harrington, the forestry member of our commission, who served two years in the Forestry Division of France, stated that during that entire period they

cut nothing but planted pine, and every time a tree was cut down another was planted in its place, and every twig was gathered up and the ground left clean to prevent any hazard of fire.

We are engaged in a mighty cause, a cause which carries to our posterity the natural resources which God has so generously given to this country. We have waited too long. We have waited until here in Pennsylvania, in Wisconsin, in Minnesota and elsewhere the timber has been destroyed. Had we known forty or fifty years ago what we know today, we would have fine forests now in all of these states.

Fish conservation can be brought about by earnest and cooperative work. The fish will never be destroyed; they hide away out of sight; we cannot find them; consequently they will always be with us. It is different with the game. We have to be exceedingly cautious, with our increased population and our implements for killing game, together with the new facilities for reaching the game grounds, or our game will surely be destroyed. We have to use exceeding care if we are to hand these blessings down to the generations that follow.

I want to thank you sincerely for this honor, and I want to thank you for bringing the meeting to our capital city next year. I assure you that we shall use every effort to make your stay agreeable and beneficial. Madison is a beautiful city, with four fine lakes, a state university, a college of agriculture, and the State Capitol. I am sure that all of you who come will be glad and will enjoy your stay with us. I thank you.

Adjourned sine die.

Immediately after luncheon the members of the Society were taken in automobiles furnished through courtesy of the Allentown Chamber of Commerce, to the private trout hatchery of Gen. Harry C. Trexler, about four miles from Allentown, where an interesting hour was spent in viewing that establishment. The party then drove to Weissport, about 30 miles distant, where the private trout hatchery operated by L. F. Grammes & Sons was visited. An enjoyable buffet luncheon was served by the Messrs. Grammes. Mr. F. G. Shaw, champion fly caster of England, gave a splendid exhibition of fly casting which proved most fascinating to the members of the Society. The party returned to Allentown in the evening.

Charles G. Atkins, 1841-1921

It is with regret that announcement is made of the death of Charles G. Atkins on September 3, 1921, at the age of 80 years, at

Bucksport, Maine. He was born January 19, 1841, near Sharon, Maine, and spent practically his whole life in the State. Mr. Atkins was one of the pioneer fish culturists of the country and although not a member of the Society recently he was long identified with the organization, having become a member in 1884. He was Corresponding Secretary from 1905 to 1910, and was much interested in and did valuable work in connection with the Committee on Foreign Relations. Mr. Atkins was Commissioner of Fisheries of Maine from 1867 to 1871 and was continuously in the service of the United States Fish Commission, and its successor, the Bureau of Fisheries, from July 1, 1872, until his retirement August 21, 1920.

Mr. Atkins did particularly noteworthy work in connection with the Atlantic and landlocked salmons. That part of the Manual of Fish Culture issued by the United States Fish Commission in 1897, having to do with these species, was prepared by him. All told, 35 articles by Mr. Atkins appeared in the publications of the Bureau of Fisheries. The Transactions of the Society contain 12 papers by him on very interesting and important subjects, the first appearing in 1874 and the last in 1913.

As a result of his article entitled "Food for Young Salmonoid Fishes," published in the Bulletin of the Bureau of Fisheries for 1908, he was awarded a prize of $150 in gold offered by the Fourth International Fishery Congress for the best demonstration of the comparative values of different kinds of foods for rearing young salmonoids.

WARD T. BOWER.

In Memoriam

CHARLES G. ATKINS

WASHINGTON I. DE NYSE

FRANK EAMES

IRVING A. FIELD

CHARLES FLEGEL

C. F. FOWLER

W. A. GAVITT

H. A. GIBB

O. C. GOODWIN

H. A. GRAMMES

J. R. HICKMAN

LARRY ST. JOHN

W. J. STARR

PART II

PAPERS AND DISCUSSIONS

A NEW METHOD OF SHIPPING LIVE FISH[1]

By Edgar C. Fearnow

Superintendent of Fish Distribution, Bureau of Fisheries
Washington, D. C.

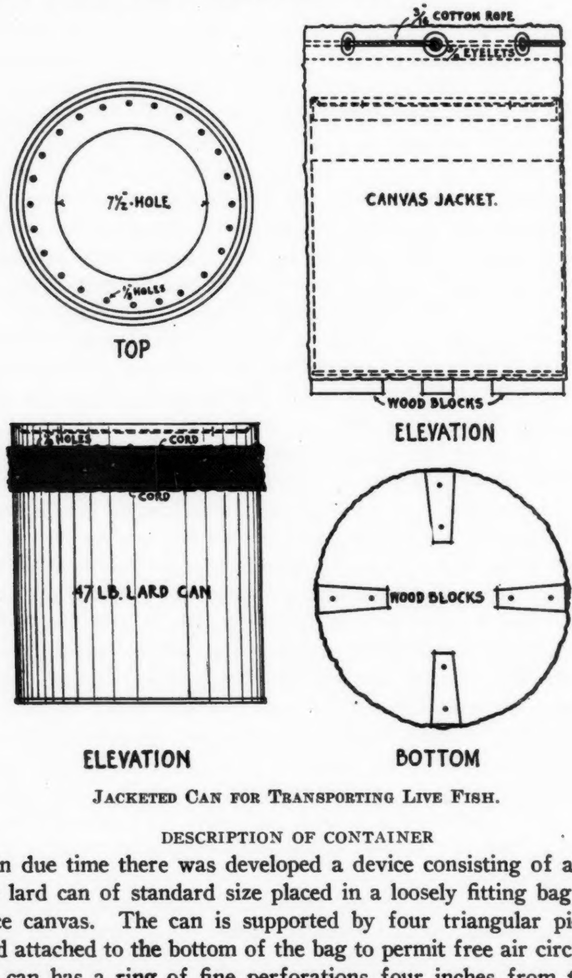
Some years ago the writer was detailed to accompany a shipment of live fish from New York to the Canal Zone. These were pond fish and included bass, sunfish, and catfish, destined to form a brood stock in Gatun Lake and other waters of the Zone. A short time after the ship left New York it became apparent that the supply of ice would be exhausted long before the end of the voyage, unless means could be found for conserving the limited amount remaining. The successful outcome of the trip was dependent to a large degree on maintaining an equable temperature of the water in which the fish were carried. The 50 cans in the shipment were arranged to occupy as little space as possible and an old sail thoroughly saturated with water was drawn closely around them. The results were surprisingly satisfactory. Instead of having to ice the cans every few hours, one icing in 24 hours was found sufficient to maintain the temperature at the desired point, and the fish were delivered at Gatun and Gamboa, Canal Zone, without undue loss.

The success of this simple expedient impressed the writer with the possibilities of applying the well-known principle of heat absorption by evaporation to a container that would be of practical value in the shipping of live fish under conditions where a rise in temperature must be avoided. Also it seemed to have direct bearing upon the problem which the Bureau of Fisheries has recently been called upon to solve, namely, how to distribute fish in ever larger numbers without additional funds to meet the greatly increased transportation charges. In view of the fact that passenger, freight, and express rates are now higher than at any period in our history, and as there is an insistent demand for economy in both government and private business, it has seemed most opportune to undertake a new method of shipping live fish without ice and, in many, perhaps most, instances, without the usual attendant. The possibilities of great saving over the present method of shipping by messenger are readily apparent.

Temperature is one of the principal factors in the transportation of live fishes. It has been noticeable for a number of years

[1] In order to add to the value of this paper, the author has incorporated certain data as to results secured after the paper was submitted at the meeting of the Society early in September, 1921.

that messengers who watch the water temperature closely are usually successful in carrying fish, while those who are constantly working with their fish, changing and aerating the water, seem to be least successful. Having this in mind, and in view of the experience on the trip to the Canal Zone, experiments were undertaken to devise a container which would meet the ends sought.



JACKETED CAN FOR TRANSPORTING LIVE FISH.

DESCRIPTION OF CONTAINER

In due time there was developed a device consisting of an ordinary lard can of standard size placed in a loosely fitting bag of 10-ounce canvas. The can is supported by four triangular pieces of wood attached to the bottom of the bag to permit free air circulation. The can has a ring of fine perforations four inches from the top, about which ring on the outside of the can is fastened a band of

cheese cloth or other absorbent material. When in use the bag is saturated with water before the shipment is delivered to the carrier; the small amount of water that escapes through the ring of perforations is taken up by the encircling absorbent material and conducted to the outer covering of canvas. The evaporation from the constantly moistened canvas is the prime factor in maintaining a lower temperature of the water. The cover provided for this container is open in the center and perforated near its outer margin. Water splashing out of the can falls back again either through the perforations or through the central opening, thus aiding, though but slightly perhaps, in aerating the water.

Experimental Results With Protected and Unprotected Containers

The table on the following page shows results of some experiments in regard to water temperatures with this and similar devices, as compared with unprotected cans.

It may be seen from the table that an even temperature can be maintained and that, when the margin between the air and water temperature is not too great, the temperature of the water may be considerably reduced through evaporation.

EXPERIMENTAL SHIPMENTS

The first shipments of live fish were the top minnow *(Gambusia affinis)*. The results in each case were highly satisfactory, as indicated by the following:

1. Edenton, N. C., to Washington, D. C. One 7-gallon can containing 250 top minnows was delivered to the express agent at Edenton at noon August 12 and was not received in Washington until noon of August 14, having been much delayed en route. Although this lot of fish was about 50 hours without attention, it arrived in good condition with a loss in transit of only about 25. It is very doubtful whether an attendant could have prevented this small loss under the same conditions. The temperature of the water in the can on leaving Edenton was 75° F. Unfortunately the watchman on duty at Washington failed to note the temperature on arrival.

2. Washington, D. C., to New York City. One 7-gallon can containing 210 Gambusia was shipped by express from Washington August 18 at 4:30 p. m., water temperature 79° F. Mr. F. W. Collins, 17 East 42nd St., New York City, to whom the fish were consigned, reported as follows: "I went to Jersey City this morning (August 19) and found the fish to be in good condition on their arrival there. The temperature was 68° F."

EXPERIMENTS SHOWING COMPARABLE RESULTS WITH DIFFERENT CANS UNDER VARYING CONDITIONS.

Day and hour.	Air temperature.	Water Temperature.					Location.	Atmospheric conditions.
		Standard 10 gal. can.	Lard can, wet sack.	Lard can without jacket.	Lard can dry canvas jacket.	Lard can wet canvas jacket.		
June 20:								
9.30 a.m.	79	48	48	....	....	48		
12.30 p.m.	90	70	62	....	....	62	In yard at	Cloudy and
2.30 p.m.	92	77	68	....	....	68	Bureau.	warm.
3.30 p.m.	80	78	70	....	....	70		Raining.
June 28								
10.00 a.m.	84	81	....	81	....	81	Indoors.	Very little air
12.00 noon	87	81½	....	81½	....	80	Tops open.	in circula-
4.00 p.m.	89	81½	....	81½	....	78		tion.
June 29								
9.30 a.m.	79	56	....	56	....	56	In shade.	Very little air
1.30 p.m.	87	68	....	68	....	66	Tops open.	in circula-
3.30 p.m.	84½	72	....	72	....	69½		tion.
July 26								
9.15 a.m.	84	....	....	80	80	80	In shade in	Weather fair.
1.15 p.m.	95	....	....	84	82	76	yard at	Slight breeze.
4.15 p.m.	94	....	....	85½	82	75	Bureau.	
9.00 a.m.[1]	83	....	....	80	78	73		
July 27								
9.30 a.m.	85	....	....	81	81	81	In sun in	Sunny and
11.30 a.m.	113	....	....	86	84	80½	yard at	breezy.
1.30 p.m.[2]	111	....	....	89	88	81	Bureau.	
4.15 p.m.	101	....	....	92	89½	80½		

[1] Following morning; jacket still moist.
[2] Moistened jacket of cans.

3. Washington, D. C., to Manchester, Iowa. One can containing 200 Gambusia left the Central Station of the Bureau at 4:30 p. m. August 18 and was shipped by express on a train at 7:30. It was delayed in Chicago 25 hours, and arrived at Manchester at 10:00 a. m. August 21, being 66 hours without attention. The superintendent reported that 100 Gambusia were alive and in good condition and that the temperature of the water was 60° F.

PRACTICAL APPLICATION OF NEW METHOD

A specific instance of the gratifying results achieved by the plan described in this paper is a shipment recently made from the Orangeburg, S. C., station. On this trip the messenger had 20 cans containing black bass and bluegill sunfish, and supplied 17 applicants at nine different points in North Carolina. He left Orangeburg at 5:30 a. m. and returned at 11:00 p. m. the same day, the cost of the entire trip being only $21.47. Had the messenger gone to every point where he had fish to deliver, the trip would have required 65½ hours, instead of 17½ hours, and the expense would have been practically double. The messenger simply went straight to Fayetteville, N. C., where a number of deliveries were made, and from that point forwarded fish to 11 different applicants. The cost of the distribution from the Orangeburg station during the fall of 1920, under the old method, was $1.57 per can of fish distributed. The records show that from July, 1921, to the close of the distribution the cost under the new method was only 90 cents per can.

From the Bullochville, Ga., station 28 shipments were made on four messenger trips. On one trip to Atlanta, Ga., 10 shipments of fish were made to points in Tennessee, Alabama, North Carolina and Georgia. No complaints were received.

In the fall of 1920 a special shipment of Gambusia was sent by messenger from Edenton, N. C., to Washington, D. C., the cost of the trip being approximately $25. Practically the same number of Gambusia were shipped to Washington, D. C., this fall in two jacketed cans, the express charges being only $1.57.

The saving of approximately 50 per cent in the distribution cost from Edenton was brought about by sending a messenger to three railroad centers, Greensboro, Raleigh, and New Berne, N. C., and forwarding the fish by baggage masters or by express from those points. Twenty-four shipments were made in this manner and no complaints were received from the applicants supplied.

The following statement shows the actual cost of making the distribution of sunfish from the Edenton, N. C., station for the seasons of 1920 and 1921:

COMPARATIVE COSTS OF DISTRIBUTION OF SUNFISH FROM EDENTON, N. C., STATION

Destination.	Number of Applicants supplied.	Number of cans.	Number of fish.	Cost.
Old Method: (1920)				
Raleigh, N. C.	6	12	1,800	$32.94
Catawba, N. C.	5	13	1,910	32.00
Chapel Hill, N. C.	8	16	2,519	20.14
Raleigh, N. C.	8	17	2,350	30.84
Mt. Gilead, N. C.	4	8	1,200	36.40
Total, 1920	31	66	9,779	$152.32
Average cost per thousand	....	....	....	$15.57
New Method: (1921)				
Greensboro, N. C.	21	21	2,650	$24.19
Raleigh, N. C.	22	22	2,125	17.49
New Berne, N. C.	19	20	3,400	21.15
Total, 1921	62	63	8,175	$62.53
Average cost per thousand	....	....	....	$7.64

In addition to the specific results secured at certain southern stations, it is expected that the method will be of special value in supplying applicants in the western and southwestern states with the different species of pond fish, most of which bear transportation very satisfactorily. The demand for catfish and other coarse species in such states as New Mexico, Arizona, and Wyoming is large, and reports received from applicants who have been supplied indicate that the results following the plantings of such fish have been particularly satisfactory. Because of the expense involved in such shipments, it has been necessary to refuse many applicants, and only those most advantageously located with reference to railroad facilities have been supplied. By means of the new device it appears entirely practicable to transport fish to applicants in those sections, carrying them in the distribution cars from the point of production to central railroad points such as Denver, Colo., and Albuquerque, N. Mex., and then forwarding the consignments by express or baggage to the applicants.

In view of the results obtained, it seems quite fair to assume that in higher altitudes, where evaporation is more rapid, the temperature can be maintained at a point sufficiently low to permit the safe transportation of the various species of trout without the use of ice or the services of an attendant.

It not infrequently happens that fish delivered in good condition to an applicant are lost in transit from the railroad station to the point where they are to be planted. The loss may be occasioned by the failure of the recipient to understand the requirements. In other instances, where fish are transported for long distances by pack animal, a method frequently resorted to by officers of the Forest Service, it is of course impossible to carry a supply of ice. In such cases it is necessary to change the water in the cans as opportunity may permit. Where fish are shipped in the new type of container a constant water temperature is assured, and as the movement of horse or vehicle insures sufficient aeration, the fish will arrive at destination in good condition.

In the case of shipments in the new container the motion of the train or other conveyance will cause the water to splash sufficiently to provide the necessary aeration, but in shipments involving long periods of quiet at transfer points aeration of the water by some means is desirable, even essential. It may be that a plan of insuring the automatic introduction of the necessary oxygen will some day be devised.[1] Cool water, however, absorbs oxygen more rapidly than water at a higher temperature, and low water temperatures make fishes less active, hence the lower temperature of the jacketed can minimizes the danger of loss during delays.

Every year a small percentage of the millions of fish rescued by the government from the Mississippi River overflow are diverted for general distribution. The principle involved in the new container is especially adapted to the transfer of fish from the collecting fields to the points where they are to be "hardened" prior to their shipment to applicants.

In order to insure proper delivery of shipments of fish, the Bureau has been sending to the applicant a telegram substantially as follows:

Answer government rate collect whether you will meet 3.25 P.M. Norfolk & Western train, Roanoke, November 2d, for fish.

Unless a favorable reply is received to such a telegram, the fish are not shipped. And to obviate any possible loss of fish through accidental failure of applicant to meet a shipment, each can is tagged as follows:

This can contains (number and species of fish) for stocking (name of water). If delivery cannot be made to consignee within one hour, the fish should be planted in the above mentioned or other suitable waters. Keep can in a current of air and in shade. Do not try to hold.

[1] Recent improvements to the shipping container herein described make it self-aerating even when not in motion.

Briefly, the device promises to make it possible for the Bureau of Fisheries to materially broaden the scope of its fish distribution, and at the same time reduce the expense connected therewith. It is not intended to convey the idea that special attendants will not be necessary in handling large shipments of fish or under particularly difficult conditions; but, by taking a large number of cans to some central point and sending the various allotments of fish to the applicants in the same manner as the car now dispatches its messengers, one man should be able to cover the territory more expeditiously and economically than is possible under the present system.

There has been heavy expense heretofore in shipments off the main railroad lines, since the attendant, because of irregular train service, frequently has been obliged to remain over night at the point where the last delivery of fish was made. By means of the simple device herein described, such shipments often can be forwarded by express, or in care of the train baggage master, at merely nominal cost.

In connection with the use of this improved container for the shipment of live fish, attention may be invited to the following advantages resulting from its use:

1. It is inexpensive; the can and jacket or bag complete costs less than $1.50. The bag represents about 65 per cent of the total cost. In short distance shipments, where express charges are not high, the cans may be returned for reuse. In cases where there would be heavy express charges, the recipient of the fish may be requested to return the bags only, by parcel post.

2. It eliminates the necessity for ice in transporting live fish. Ice is expensive, and there are many recorded instances of experienced men losing fish because ice was not available and there was no other known means of preventing the water temperature from rising beyond the point of safety.

3. Since water temperature is the important consideration in the transportation of fish, it follows that the principal duty of the person in charge of live fish shipments is to maintain a suitable water temperature as far as is possible. As a suitable temperature is automatically maintained in the jacketed can, the necessity for an attendant is eliminated, thereby effecting a saving of railroad fare and subsistence of messenger, and other incidental items. The cost of the shipment will be represented by the express charges only, or a nominal fee to baggage masters. As mentioned previously, the need of an

attendant with large shipments of fish, particularly over routes involving a number of transfers, is recognized, but in any event, the jacketed can will still have a distinct advantage over the cans in common use.

4. The underlying principle involved in the plan is the cooling effect of evaporation, and since heat greatly stimulates evaporation, it would seem that the principle might be successfully taken advantage of, within certain reasonable limits, in almost direct ratio to the need. It is not claimed that the device is perfect, nor have its full possibilities been exhaustively demonstrated, but the results obtained so far in maintaining a lower temperature of water in shipments of live fish without an attendant, warrant its general adoption.

Discussion.

Mr. G. C. Leach, Washington, D. C.: On September 2d a shipment of 50 bass was sent from Logansport, Ind., to Washington. They were in what is termed a 50-pound lard can, jacketed according to the description given in the paper. They arrived in Washington, after having been on the road 24 hours, with a loss of but 10 fish. The temperature on arrival at Washington was approximately 62° F., about the same as when the shipment started. The loss of the 10 fish was probably due to the fact that the can remained in the station about an hour and 15 minutes, the water being in an inactive state.

Mr. Fearnow does not claim that his device is going to solve all the problems in regard to the transportation of fish, but he believes that a messenger so equipped may go to some central point and distribute fish east, west, north and south by express, saving possibly several trips. He does not claim that the jacket on the can is going to be effective when the outside temperature is below 50° or 60° F. It will be more valuable during the very warm weather in the summer, and it is going to be very successful in making shipments of trout or bass for a period of four or five hours, but it is not expected to cover a period of 24 hours, though under certain conditions we can ship warm water species that long with considerable success. The can offers possibilities for shipment of goldfish and top minnows.

Mr. J. W. Titcomb, Albany, N. Y.: With one exception, the experiments were with warm water, above 60° F. Would it help to keep the temperature down in the case of trout, starting with 45°?

Mr. Leach: The canvas jacket around the container absorbs the water that slops out, thus keeping it saturated. The evaporation will cause the temperature to rise slowly, and if the start is with water at 48° F., four or five hours at least will elapse before it gets up to 53°, or before it would be injurious to the trout. It is not claimed that it will carry trout as far as it will bass. We realize that the express companies are slow in handling the fish, therefore, to expedite the matter we expect the messenger, when he arrives at the central shipping point, to put the cans in the express car himself. I do not believe more than 5 per cent of the applicants fail to

meet the fish. In making express shipments it would be necessary to get in touch with the applicant and be assured that he would meet them.

MR. TITCOMB: I think this is a mighty good paper. As bearing upon possible loss of fish, in the case of express shipments would you call upon the express company to deliver the fish if the applicant was not at the depot?

MR. LEACH: In that event a tag will give full instructions for placing the fish in some suitable water. In making the distribution in certain sections of the country, care will be exercised not to put bass in trout waters or mix the species. But we expect to have every assurance from the applicant that he will meet the fish.

MR. J. P. WOODS, St. Louis, Mo.: Have any experiments been made to show the exact life of a can of fish, how long they would live under present practice?

MR. LEACH: We have made some experiments. We feel that fish placed in a can in which the water is not active will soon suffocate. The water has to be agitated by rocking back and forth, and also in motion to moisten the outside jacket. If 100 bass two inches long were placed in such a container holding about six gallons of water at a temperature of 55°, not more than 50 fish would survive when the temperature increased to 80° F. If the water were not active I believe the temperature would reach that point in a few hours, when the fish would die. All of the trout would die in two hours and the bass in three or four hours. I do not believe you would lose them in one hour, as the temperature would not rise that fast. Trout would die at 65° F.

MR. CARL KRAIKER, Philadelphia, Pa.: Farmers have used a canvas sack three-quarters of an inch thick in shipping milk all through the upper part of New Jersey, and in Pennsylvania and New York. The milk in its raw condition, after being cooled in a stream or spring house, registers about 38° F. It is shipped with a wet jacket, closely packed together in unrefrigerated cars, and by the time it reaches Philadelphia for use the temperature has risen only three to five degrees, although in transit four or five hours.

MR. LEACH: The jacket on the milk cans is more expensive than that on the 50-pound lard cans. Ours is very simple, a mere sack over the can tied with a puckering string. It helps to hold the lid down, is very easily made, and is inexpensive. The cans are small, about 12 inches in diameter and 15 inches high, with handles on each side, and with six gallons of water weigh about 50 pounds.

Some years ago, we experimented with a thermos can. We put a lining in a 10-gallon can, allowing three-quarters of an inch of dead air space all around. It was made perfectly air tight. We found that the temperature would gradually rise. It would go up as the exposed surface absorbed air. I do not think you could make a vacuum can that would be successful, because the water would gradually absorb a little of the heat from the air at the neck of the can. We also tried to insulate a can, with a jacket outside, but it increased the diameter and added weight. Our latest cars now carry 140 cans, and we cannot afford to increase the outside diameter nor decrease the inside diameter of the can by adding a dead air space. We have found recently that we could cut four inches off the 10-gallon

cans, making them 8-gallon cans, and get just as good results. The weight also is reduced. It will both decrease the cost and greatly improve the cans. We are also going to eliminate the narrow neck around the top of the can, which will save two inches of height on our 10-gallon can and will facilitate aeration. It has been proved that just as many fish may be carried in the 8-gallon can as in the 10-gallon can of the same diameter. Diameter counts more than height.

MR. TITCOMB: The American Balsa Company constructs a box of balsa wood from Central America. It is as light as bark, but comes from the tree itself rather than the bark. It is very good for insulation purposes. They propose to use these boxes for transporting perishable merchandise, such as chickens which have been chilled. If you have a box two feet long and 15 inches wide, it will take only a few cents postage, it is so light. A company was formed in New York recently, headed by Kenneth Fowler, which has a concession from the American Balsa Company for the use of these boxes in the transportation of fish. They propose to have sanitary plants for dressing the fish, and for chilling the meat after the skin and bone are removed. Then, wrapped in paper packages it is put into these balsa boxes and sent by parcel post, special delivery. The boxes will hold the temperature, so that fish can be shipped from New York to Chicago and be delivered in good condition. The temperature changes very slightly, if at all, during a journey of 48 hours. It presents great commercial possibilities in the handling of dressed fish. Possibly a jacket of balsa wood around a fish can would not increase the weight perceptibly, and would prove more desirable than canvas, especially where messengers accompany shipments.

I am pleased at the innovation introduced by Mr. Leach in reducing the height of the can. If we could have the cans twice the diameter and cut the height down, we would get much better results from the same amount of water.

MR. KRAIKER: In transporting fish to Philadelphia we used 50-gallon cans and boxes generally about 26 or 28 inches deep by four feet wide and six or seven feet long. We had paraffin canvas cut to fit the boxes and always used an air pump. After loading the salt-water fishes on numerous occasions we left Atlantic City at 3 o'clock for a journey of 68 miles, and being able to make 10 miles an hour with the truck, arrived at the Fairmount Park Aquarium with but a small loss. The highest percentage of dead was in the cans, while in the canvas-covered box the loss was very small. In the transportation of any fishes in warm weather the temperature of the water is driven higher by the warm air forced through by the pump; this does the greatest damage, according to my experience in transporting fish for the last 10 years.

THE DOMESTICATION OF LANDLOCKED SALMON BREEDERS

By W. M. Keil
Consulting Fishculturist
Tuxedo Park, N. Y.

When the writer first began the propagation of landlocked salmon at Tuxedo in 1899, he often wondered why there were no hatcheries anywhere in the United States that had domesticated this fish. It was a splendid sporting variety, and there was a steadily-growing demand for the young fish for stocking purposes; yet all hatcheries that handled the eggs and reared the fish depended entirely upon the collection of wild eggs for their supply. At that time there was no literature available on the subject, nor is there today; and what information the writer has been able to procure regarding the attempts of others to domesticate this fish was received through correspondence. After twenty-two years of continuously handling this salmon under domestication, the writer is no longer in doubt as to the reasons for all other hatcheries giving it up in disgust after a short trial. The Tuxedo Club Fishery is, as far as can be ascertained, the only one in the country at which successful domestication has been carried out. This has been accomplished not because the conditions at this hatchery have been more favorable, nor by reason of any special ability of the fish culturists, but simply through a dogged determination that it could be done, and a belief that through domestication would come an improvement in the species.

The fingerlings at the Tuxedo hatchery today are the fifth generation of domesticated fish that have never left the hatchery pools. They are infinitely superior in every way to the progeny of wild fish for handling under artificial conditions, and instead of deteriorating from inbreeding, are improving with each generation in color, growth, and resistance to disease. Our experiences in the long up-hill fight to secure these results should prove interesting to many persons.

When the writer took charge of the Tuxedo Fisheries in 1899 there were in the hatchery pools a few hundred undersized yearling salmon,—left-overs from the lot that had been put out the fall before. The eggs from which they were hatched had been obtained from the Bureau of Fisheries station at Green Lake, Maine. They were a miserable looking lot of fish to hold for breeders, but they were put into a small pool by themselves and special care was taken of them in regard to feeding, cleaning, and frequent salt baths. They

kept dying off, going blind, and developing thyroid tumor until we had but eight fish left. The first to become sexually mature was a male in the fall of 1902 at the age of four years and eight months. The following fall we had three ripe males and two females with developed eggs. Of the three remaining breeders two had turned black from blindness and the other degenerated into a "racer." The ripe males and females were placed in separate raceways for daily observation, and on November 2nd one of the females had every appearance of being ready for stripping. The eggs had loosened and the fish had that soft, flabby feeling that denotes ripeness to the experienced spawntaker. None of the males seemed very ripe, but after extracting a few drops from each into the pan, a female was picked up in the expectation that the eggs would flow freely. Efforts were unavailing for even considerable pressure would not start them and rather than take chances of injury, the fish was put back for the next day, although it was known that the eggs should come out. The following day the abdomen of this fish had distended and had the hard, firm feeling of over-retention, while the other female's eggs had loosened and dropped down. Again no eggs could be obtained from either fish, although they were unquestionably ripe.

It was then decided that the difficulty was in the ovipore, and that this opening was not of sufficient size to permit the free passage of the eggs. Casting around for some means of getting out these eggs without injury to the fish, there was finally conceived a method of enlarging the genital pore without rupturing the delicate membranous wall surrounding it. A common medicine dropper—one drawn out to a very small and smooth point—was filled with warm water and carefully introduced into the ovipore, working it in slowly to its largest diameter. After remaining a few seconds, it was removed, and to our great satisfaction the eggs flowed as freely as from a ripe brook trout. Whether the warm water in the dropper had a relaxing effect on the muscles, or whether the action was purely mechanical in its stretching of the tissue, was not then and has not since been determined; but many hundreds of later experiments in the use of this improvised speculum has shown that better and less injurious results are secured, if the dropper is first filled with fairly warm water.

The majority of the eggs from both females were taken at this first stripping, and the remainder in a few days following, without again having to resort to the use of the dropper. From these two fish 2,106 very inferior looking eggs were taken. A great many of

them had white spots on the shells, and there were a dozen or so of glassy, opaque ones. From these eggs 1,450 spotted-sac fry were hatched, and of these about 600 were reared to the yearling stage. The two female breeders did not develop eggs again until two years later, but we had no difficulty in getting out these eggs, although they were not much better in quality than at first. We had about 200 of these second generation fish left when the first female developed eggs in the fall of 1908. This illustrates the small percentage of females that reach sexual maturity in their fifth year, for the other females of this lot of 200 fish did not spawn until the following fall —5½ years after hatching. This one, poor, lonely female was given a good deal of attention, for much of the success or failure of the entire undertaking would be indicated by her deliverance and the condition of the eggs. When the time arrived for the eggs to come out, the writer was very much discouraged to find that they could not be taken with any more freedom than had been experienced with her progenitor almost five years before. The eggs though, were much better in quality, color, and percentage of fertilization; and the resulting fry showed greater vitality and more rapid growth. When the remaining females of this lot of fish ripened the following fall, results were more satisfactory, for from among the 36 females that had eggs in them, we were able to strip four without the use of the dropper, although more force than is usually applied was necessary.

This is perhaps a good place to mention the interesting fact that with none of the hundreds of females that we had operated upon, was it ever found necessary to dilate the ovipore a second time. With the stripping of the third generation of fish in the fall of 1913 and of 1914 this difficulty of a constricted ovipore seemed overcome at last, and with the fourth generation of breeding fish in 1918 and 1919 it had entirely disappeared. Why such a physical abnormalty should exist even with salmon reared under artificial conditions, the writer has never been able to understand, for it is not found among the domesticated breeders of other Salmonidæ. We all have had experience with examples of plugged fish, but this condition was entirely different. Many fish with well-developed eggs were sacrificed in an effort to discover by careful dissection the existence of a false membrane stretched across the internal duct; but nothing of a hymenal character could be discovered. It may be that the development of the eggs under artificial feeding in the fish of the earlier generations, was proportionately more rapid than the general development of the rest of the body, for while the sal-

mon averaged only about 2½ pounds, the eggs were 26/100 of an inch in diameter.

Our experiences of over twenty years with these fish has brought to light many interesting facts about their growth, feeding habits, reproduction, and migatory movements. The Tuxedo hatchery is supplied with water from Tuxedo Lake; therefore the growth of our fish during the early spring, fall and winter is necessarily much less rapid than at hatcheries using spring water. The development of the eggs is also very much retarded, those taken about the first of November not hatching until the latter part of February. The food sac of the fry is usually absorbed in about eight weeks; the salmon average only about three inches at one year old, and from six to nine inches at two years. Under these conditions, the records show that only 10 per cent reach the reproductive age in their fifth year, or at the actual age of four years and eight months from hatching. Under natural conditions, it is believed that this is the average age at which landlocked salmon reach sexual maturity. Approximately 95 per cent of these fish spawn only once in two years. Occasionally a fish will spawn two years in succession and then skip a year; but with the domesticated fish at least, this salmon must be regarded as a biennial spawner.

One of the greatest difficulties we have experienced in the cultivation of landlocked salmon breeders, has been the heavy loss of ripe males from fungus. We have tried every conceivable method of both prevention and cure without any great degree of success. Several weeks prior to the spawning season, the pool containing the breeders is drawn down and those fish showing signs of ripening are taken out and the sexes separated. The fish are handled with extreme care, being dipped out with and held in soft, rubber-lined tubs while they are looked over. It does not seem to make any difference whether they are handled or not, a large percentage of them develop fungus so badly that we can seldom save more than 50 per cent of the males that ripen. We have tried leaving all the males that we think we shall not need, in the large breeding pool where they are held throughout the year; but even there where they have plenty of room and no reason for injuring themselves, many of them become covered with fungus and have to be thrown away. We have tried dipping them in salt and other fungicide solutions every day, varying the strength of the solutions with different individuals; in fact we have tried every method of prevention and cure known to fish culturists to combat this trouble, without any appreciable results.

With the females, we have little or no trouble from this source, although they are handled and rehandled a great deal more than even the males used for stripping. Once in a while one of the females will get patches of fungus on her head or tail, but as soon as she is relieved of her eggs, the fungus disappears, and the abraded skin rapidly heals over. We always have a surplus of male fish coming on each year, for when the two-year-olds are sorted out to be saved for breeders (as is done each year), the sexes cannot be distinguished and lately the writer has taken to putting out into the lakes all ripe males which it is thought will not be required. This is not good fish culture, for more fish are being carried as breeders than would otherwise be needed; but until some better method of overcoming this trouble is worked out, it is the best that can be done. Our domesticated steelhead breeders are carried year after year without loss from this cause.

The landlocked salmon is without doubt the most susceptible of any of the Salmonidæ to external parasitic disease. This extreme susceptibility is occasioned by the almost entire absence of the usual protective mucous covering, or so-called body slime, which in connection with their characteristic habit of resting on the bottom with fins motionless, makes them an easy prey for the millions of pathogenic bacteria and protozoa that lurk in this decaying matter. Their comparatively enormous fins become easily abraded when crowded together in narrow quarters, and present a favorable seat for the origin of parasitic troubles. Most of these external diseases respond readily to treatment with gasoline or potassium, and if taken in time seldom reach a serious stage.

With the first, second, and third generations of our domesticated salmon, we experienced a great deal of trouble from thyroid tumor. In the second generation especially, as high as 15 per cent developed this growth in the years they were retained. These fish were all destroyed as soon as the trouble was discovered, and no eggs or milt was ever taken from a fish so affected. For the past six years there has not been found a single fish, either among the breeders or the thousands of two-year-olds planted, that had the least indication of this disease.

Space will not be taken in this paper for an explanation of the rearing methods, water temperatures, foods, tank sizes, and depths found best suited to the propagation of this fish. It is hoped to give details regarding these matters at some later time.

All our salmon and steelhead trout are reared to the beginning of the smolt period before they are turned out into the lakes. If

really good results are to be expected from the planting of these varieties in deep lakes containing no permanent tributary streams, the fish must be held, regardless of size, until they have passed the parr stage and begun to take on the silvery coloration of the smolt. That this is so, the writer has proved to his own satisfaction; but his research work along these lines has not been carried far enough, so that a reasonable explanation may be offered to substantiate the truth of this statement. Experiments are being carried out this summer at both Tuxedo and Sterling Lakes in an endeavor to clear up some of the complex biological and physiological factors involved in this problem, and it is hoped that by another summer many of these little-understood morphological changes in the life of these fishes will have been solved.

Discussion.

MR. J. W. TITCOMB, Albany, N. Y.: Mr. Keil is probably the only man in this country who has successfully bred landlocked salmon under domestication. For a number of generations, he has done it very successfully. I have a letter here from him in which he speaks of the results with salmon and steelhead trout in lakes:

> Since we have put smelt and shiners into our lakes, the trout and salmon are running as high as 5 pounds. Sterling Lake, which I mentioned, belongs to the Midvale Steel Co., and lies west of here about four miles. It is about the same size as our large lake (2 miles long by ¾ wide) but the shores are entirely wild and covered with heavy timber. It is clear as crystal and about 150 feet deep. It has no inlets, but a large stream runs out at all times. In the spring of 1919 I planted 3,000,000 smelt fry in this lake and in the fall of that year took over 4,000 salmon and steelhead averaging about 6 inches. This spring these fish were being taken as heavy as 4½ pounds, and one day when I was fishing alone I caught four running from 2½ to 4 pounds. These salmon in Sterling Lake are the finest proportioned fish I have ever seen, plump as butter, and as bright as a bar of silver. I thought that salmon could not possibly be finer than those I caught at the Averill Lakes in Vermont, but these are far better. The chemical analysis of the water at Sterling is entirely different from that of Tuxedo.

Some of you know the difficulties of getting landlocked salmon introduced into your waters. The State of New York has been planting salmon in its lakes for the past 25 or 30 years, and today there is not a public lake in the State where we have any salmon fishing. Every year from 20,000 to 30,000 are hatched, and during the last four years we have put out as high as 100,000 landlocked salmon, chiefly in Lake George, with an annual yield of perhaps 10 adult salmon a year to the anglers. The fish were formerly planted in the lake, and later in the tributary streams, where I believe they should be planted. A good many were caught from the tributary streams when they still had the red spots which they carry until eight or nine inches long. After the investigation we decided it was useless to attempt to stock a lake like that, unless we could carry the fish through the smolt stage. The State today has one lake entirely under its control, posted and screened, where they have been planted for

three years to determine the possibility of developing a source of supply for eggs.

The salmon have been introduced into many other waters. Vermont has done extensive work in the propagation of salmon, but has succeeded in really getting them established in only two lakes, which are connected. New Hampshire had varying success with the salmon at different times and then they disappeared. Maine seems to have kept up the fishing in the original basins where these fish were found, and has discovered the danger of trying to have salmon and brook trout in the same lakes. Attempts to extend the range of salmon to meet the demand of anglers, by planting in lakes of other watersheds than those where they are indigenous, resulted in salmon fishing but at the sacrifice of the trout; so they discontinued planting in trout waters.

Mr. C. O. Hayford, Hackettstown, N. J.: Landlocked salmon were introduced in the Rangeley Lakes in 1880, to the detriment of the brook trout. In that section the salmon now predominate in what were once the best brook trout waters and it is very easy to see the reason. Brook trout in the Rangeley section spawn about September 28th, and the landlocked salmon from about October 15th to November 1st, both using the same spawning grounds. Thus when the salmon arrive on the spawning beds and sweep the gravel before spawning, they destroy many brook trout eggs. In four years I probably handled 2,000 salmon, ranging from 2 to 18 pounds, and seldom found any difference in the free flow of the eggs from large fish. Once in a while we would get a salmon that would strip very hard.

Dr. D. L. Belding, Hingham, Mass.: Several important points have been brought out by Mr. Keil in this interesting paper. One of our fellow members, Dr. David Marine, conclusively demonstrated that thyroid tumor may be eliminated or controlled by the use of small quantities of iodine in the water. This work was carried on as part of an experimental investigation of the cause of goitre. As far as I know, it was permanently cured. Even if the disease were only arrested, the effect could be maintained by the occasional addition of iodine to the water. At the present time, experimental administration of minute doses of iodine two or three times a year to school children in goitre districts is proving successful.

Mr. Keil suggested that the reason landlocked salmon were especially susceptible to disease might be due to the lack of a slimy mucous covering. In this connection, the following observation on the effect of copper sulphate on adult brook trout, rainbow trout, and landlocked salmon may prove of interest. All three species were confined in a single pool, which accidentally received the copper sulphate. All the landlocked salmon and over 50 per cent of the brook trout died, while the rainbow trout survived, demonstrating that landlocked salmon were more susceptible to chemical pollution than either of the other species. Possibly Mr. Keil's theory of the lack of mucous covering in landlocked salmon would also explain its susceptibility to pollution.

At the East Sandwich state hatchery in Massachusetts, chinook salmon matured at the age of four years. Some were allowed to spawn in the pools, and others were stripped. All immediately became covered with

fungus, wasted away, and died. Probably this is characteristic of the species and not due to the long, arduous migration from the Pacific Ocean to the spawning grounds.

In connection with the susceptibility to fungus, of both the eggs and the adult landlocked salmon, I would like to ask various fish culturists present whether they consider fungus a primary or a secondary invader; that is, whether they consider it a primary cause, or secondary to other diseased conditions.

MR. HAYFORD: At Hackettstown if the brook trout after being stripped are placed in spring water which is 52° F., they soon become badly fungused, but when placed in brook water at about 42° to 44° we have no trouble. I think it is a case of temperature rather than handling.

MR. TITCOMB: Young landlocked salmon seem to be more susceptible to fungus than any of the other Salmonidæ I ever handled. At hatcheries holding fish to yearling size, more *Saprolegnia* is experienced with the salmon than any other species. It comes on very suddenly. Young salmon seem to thrive better in warm water than trout.

MR. G. C. LEACH, Washington, D. C.: Very little difficulty is experienced in handling salmon at our Green Lake station in Maine, as the eggs are taken in the fall when the water is cold and there is little fungus. We have little trouble with young fish there because they are hatched and reared in the natural water temperatures. At the station at Manchester, Iowa, rainbow trout very much fungused after the spawning season were placed in the creek in water considerably cooler and of greater volume than in the ponds and where conditions were natural, and they soon developed into healthy specimens. This indicates that natural conditions have a tendency to discourage fungus. If landlocked salmon are held and reared in artificial ponds, a great deal of trouble may be expected. One reason why the introduction of this species into other waters has failed is because of the lack of natural food, especially smelts.

MR. TITCOMB: We never attempted to introduce salmon into any water where we did not first introduce the smelt. The Adirondack frost fish, which averages from six to nine inches in length, is less destructive to other fish, and it is quite similar in appearance to the smelt, except that it does not have the sharp teeth of the latter.

MR. E. W. COBB, St. Paul, Minn.: Referring to the Green Lake hatchery, old settlers used to tell me about catching cart loads of landlocked salmon in the rapids below Rocky Pond and using them for fertilizer. During the three years I worked there those rapids were the source of the water supply for the Green Lake hatchery, and were originally one of the spawning grounds of the salmon. We reared seven-inch landlocked salmon in the hatchery ponds the first summer, in some cases. Those reared in the troughs averaged about half the size of the salmon in the ponds, but the loss in the troughs was probably not over 25 per cent of that in the ponds. The water would run up to 86° F., and there was some fungus. Unless the salmon were fed for about 24 hours a day, they would begin biting each other, thus starting the fungus growth, which was inclined to spread.

MR. N. R. BULLER, Harrisburg, Pa.: Years ago the State of Pennsyl-

vania hatched and distributed a great many landlocked salmon fry without any apparent results. A few years ago several ardent fishermen from the Johnstown region came back from a fishing trip to Maine imbued with the idea that landlocked salmon were the particular fish for Pennsylvania waters. The Department discouraged them and cited the experiments years before. But they were persistent and the Department hatched some eggs which they purchased. The fry were planted in ponds in Cambria County after being held about two months in the hatching troughs. About two years later I received from one of these gentlemen two salmon 14 inches long taken out of the pond. We have been putting in about 40,000 for three years now. Under the circumstances it does not appear to be money well expended to endeavor to stock the ponds of Pennsylvania with landlocked salmon; the stocking which these parties have had us do for them merely results in the catching of 18 to 20 fish a year from an artificial pond built upon a stream, with a maximum depth of about 30 feet, and it seems to me that the annual catch does not warrant much expenditure along that line.

Mr. Leach: It is a question whether the salmon run down stream; they may do so in search of food or to spawn. They go down in the fall of the year but I do not know whether it is a well-defined movement. They get into the current and may drift over the falls of Grand Lake Stream in search of spawning grounds; however not all fish passing over the falls are lost, but it is so serious that the State of Maine is considering the screening of the outlet of Grand Lake Stream.

Dr. Edward E. Prince, Ottawa, Canada: The Department of Fisheries in Ottawa tried year after year to secure adequate supplies of landlocked salmon from the Chamcook Lakes in New Brunswick. I, myself, took charge of operations there in 1904, and I found that the salmon were migrating from the lower to the upper lakes. We secured our best catch of parent fish and take of eggs in the narrow connecting stream. There were migratory movements, at times up, and I suppose at some other time in the year they must descend as the salmon can go down to the sea if they wish. There is no absolute barrier. There is a very swift, short stream down to Passamaquoddy Bay, but I have not heard of any fish descending to salt water. Mr. E. T. D. Chambers, who devoted a great deal of attention to the landlocked salmon of Quebec, is here and I think perhaps he may know whether the salmon descend to Lake St. John. Are they ever known to go from the Grande Decharge?

Mr. E. T. D. Chambers, Quebec, Canada: It is reported that they go almost as far as the heaviest of the rapids. There is no reason why they should not, if they desire to do so.

Dr. Prince: That is a most remarkable case. Lake St. John is up the great Saguenay River, one of the most remarkable rivers in Canada. The discharge from Lake St. John into the Saguenay is a cascade of the most gigantic and terrific character. Mr. Chambers thinks that these Ouananiche, as we call them, can reascend. They are a very strong swimming fish, of course, but the Grande Decharge is a terrific cascade.

We have had our difficulties in Canada in trying to obtain adequate supplies of eggs. There is a lake near Ottawa, in what is called the Gatineau region, 800 miles from the regions where landlocked salmon

occur, which was planted a few years ago with this species. I have reports that the planting has been a success, and quite a number of landlocked salmon are being taken. It is a mountain lake, very cold, and abounding with landlocked smelt, a very important point. These smelt occur all of this great distance from the sea.

I cannot understand why the landlocked salmon males should be difficult to distinguish from the females. The ripe males that I have seen in Canada are different from the females and rather like the humpback salmon of the Pacific Coast. The species is very susceptible to disease, and I imagine, from the experience we have had in Canada, that it is a secondary disease, because we have observed very closely our fish in the Chamcook Lakes, and the fungus does not seem to affect them at all. Any fungus that I observed in the ordinary sea salmon has been due to wounds, either to the scraping of the skin by nets or by the males fighting and injuring each other.

MR. CHAMBERS: I made the statement in answer to Professor Prince that the fish could ascend the Grande Decharge. I must explain that there is a small body of water, called the Petite Decharge, which is less violent and affords different passages for the fish, especially in many places where it is impossible to take the steep falls immediately below the Grande Decharge. It is the Petite Decharge which the fish probably take.

In regard to landlocked salmon, quite a serious thing is occurring now in our lakes through action of the Dominion authorities, in giving us a few hundred thousand sea salmon eggs each year. The Province of Quebec is hatching the eggs and planting them in inland waters, whence they do not descend into the sea at all, and so I do not believe there is any chance that these fish breed. They have been taken up to five to seven pounds, and in some cases even more. In Lake Memphremagog, where they are planted, a few from five to seven pounds are taken almost every summer.

CONCERNING HIGH WATER TEMPERATURES AND TROUT

By G. C. Embody

Cornell University, Ithaca, New York.

We often use the terms "warm" and "cold" water as an indication of the suitability of streams and lakes for various kinds of fish. These of course are only relative in meaning, and the question naturally arises as to what temperature we should take as the dividing line between warm and cold waters. We speak of such forms as the various trout, salmon, and whitefish as cold-water forms because they live and grow at a normal rate, and reproduce in waters of comparatively low temperature. On the other hand, we consider yellow perch, bass, sunfish, and bullheads warm-water forms because their life activities take place best in warmer waters. The latter forms will live and often reproduce in a temperature suitable for trout, but it has been generally believed that they will not grow at a normal rate in so-called cold waters.

From a perusal of the literature on the subject of fish culture, the impression came upon me that temperatures of 68° and 70° F., were generally regarded as near the dividing line between cold and warm water, these temperatures having been used possibly more often than others, as the maxima for brook trout water.

The following notes are offered, merely upon the supposition that the above impression is correct. They are based upon many temperature readings taken in streams of Tompkins County, New York, and in the experimental fish hatchery of Cornell University. The records include readings taken on the hottest summer days of the last three or four years. In saying, hottest summer days, reference is had to those days during which the air temperatures ranged from 90° to 101° F.

Let us refer at first to an experiment carried on in one of the ponds on the fish hatchery grounds. This pond was 50 by 150 feet and had a maximum depth of 4 feet. It received water from a creek in which temperatures as high as 83° F., had been taken in previous years and was thus considered a warm water pond. In June, 1920, 225 small fingerlings equally divided between brook, brown, and steelhead trout were planted. There were also added eight 3-year-old goldfish which spawned several times, and about 200 young bullheads at the swarming age. The water temperatures ranged between 69° and 81.5° F., during July and August. There

were ten days in July and seven in August when it exceeded 77° and on three days it was above 80° F.

In April, 1921, the pond was drained and the fish counted. The results of the experiment appear in the following table:

EXPERIMENT WITH VARIOUS SPECIES OF FISH IN WARM-WATER POND

Put in, June, 1920	Taken out, April, 1921.
200 bullheads 1 inch long.	150 bullheads 3 inches long.
8 goldfish breeders.	78 goldfish over 3 inches long.
75 brook trout 1½ inches long.	47 brook trout 3 to 6 inches long.
75 brown trout 1½ inches long.	37 brown trout 2 to 6 inches long.
75 steelhead trout 1½ inches long.	52 steelhead 2 to 7 inches long.

It will be noted that the bullheads grew at a normal rate and the mortality of 25 per cent was not unusually high. The great loss in goldfish was no doubt due to the appetites of the trout. Although there was great individual variation in the size of the trout, it was no greater than has been observed in the hatchery where grading is not resorted to. This variation is a perfectly natural and common phenomenon among trout. Many of the trout were fully as large as those of the same age occurring in our best streams.

The point which it is desired to bring out, is that here was a pond with mud bottom in which both warm and cold-water fish lived and grew normally. The temperatures up to 81.5° F., were not too high nor of long enough duration to kill the brook trout. The lower temperatures down to 69° were not so prolonged as to materially retard the growth of the bullheads. The conditions were thus suitable for the trout as well as the bullheads and it would seem to indicate that so far as the temperature factor is concerned, trout may be produced in ponds in which the water is much warmer than has heretofore been thought possible.

In the streams in the vicinity of Ithaca, New York, the highest temperature in which brook trout were actually found in numbers was 81° F. (Van Pelt Brook, August 6 and 7, 1918.) In other parts of this stream 83° was frequently noted but not in any case where brook trout were actually present. This brook, however, is considered an excellent though small brook trout stream and the catches from year to year fully bear out this belief. In other brooks equally good for brook trout fishing, temperatures of 77° to 79° F., were frequently recorded in places where brook trout were observed in abundance. There are more than twenty-five streams in Tompkins County, New York, now containing brook trout, and it is an exception indeed to find one whose highest summer temperature does

not exceed 75° F. in sections where brook trout commonly occur and apparently thrive.

The limiting temperatures are higher in the case of brown and steelhead trout. Temperatures as high as 83° F., for the former, and 85° F., for the latter were recorded.

The spring and summer of 1921 has been a particularly good one in which to test out various temperatures on trout, because of the unusually prolonged warm weather in May, June and early July. The water temperatures ranged from four to six degrees higher than normal during this period.

Early in May, some brook, brown, and steelhead trout were placed in wood races 4 feet wide by 20 feet long, supplied with creek water whose temperature was known to be high in summer. Everything progressed smoothly until June 27 when at a temperature of 83.3° F., the brook trout became greatly distressed and refused to eat. The table which follows records the daily water temperatures and the progress of events from this date until the end of the test.

EFFECT OF VARIATION IN TEMPERATURE ON BROOK, BROWN, AND STEELHEAD TROUT

Date.	Minimum temperature	Maximum temperature	Effects
1921	° F.	° F.	
June 27	69.8	83.3	Brook trout distressed.
28	71.6	79.7	Brook trout recovered and feeding.
29	68.9	80.6	Apparently normal.
30	71.6	78.8	Apparently normal.
July 1	70.7	79.7	Apparently normal.
2	69.8	80.7	Apparently normal.
3	71.6	84.2	Brook trout 20 per cent dead. Steelheads and Browns distressed.
4	70.7	82.4	Brook trout 50 per cent dead.
5	71.6	83.2	Brook trout all dead.
6	71.6	85.5	Brown trout 50 per cent dead. Steelhead trout 20 per cent deal. All others distressed.
7	75.2	87.	All trout dead.

The brook trout passed through a temperature of 83.3° F. without loss, but with evident distress and failure of appetite. They apparently recovered on a drop of nine degrees over night and a maximum of 79.7° the following day. They lived through five succeeding days with the maximal temperatures ranging from 78.8° to 80.7° F., but began to die at 84.2° (mortality 20 per cent). None died the following day, July 4, at 82.4°; but on July 5 at a temperature of 83.2° F., the mortality was 100 per cent.

The brown trout acted in a normal manner until July 3, when distress and loss of appetite occurred at a temperature of 84.2°. They seemed to recover during the next two days with maximal temperatures of 82.4° and 83.2°, respectively; but on July 6, 50 per cent of them died at 85.5°, and on the following day at 87° the mortality was 100 per cent.

The steelhead trout followed very closely the browns, with distress at 84.2°, 20 per cent mortality at 85.5°, and total mortality at 87° F.

The previous year, 1920, a similar experiment was tried, but the highest water temperature recorded was 81.5° F. A few of the brook trout were distressed and refused food, but recovered completely during the next few days at maximal temperatures from 78° to 80°. The browns and steelheads were not disturbed by a temperature of 81.5° and continued to eat normally throughout the summer.

It must be understood that the foregoing notes do not prove that all strains of brook trout will stand temperatures of 80° F., and above. Undoubtedly there is much variation in this respect just as we find great variation in the rate of growth, in the behavior of trout to current and light, and variation in power of resistance to disease germs.

Nor may we assume that brook trout will thrive in any pond or stream whose temperatures do not exceed these uppermost limits. Waters vary greatly in oxygen and carbon dioxide content, and these gases may be present in insufficient amounts in one case or too great amounts in the other to permit trout to live even in the low temperatures of the average trout hatchery.

So far as temperature alone is concerned, however, it is writer's opinion that we have been a little too conservative and that we shall have to revise to some extent our notions as to the meaning of the terms, warm water and cold water.

Discussion.

Mr. J. W. Titcomb, Albany, N. Y.: Dr. Embody expressed the idea very well when he said that the rainbow trout he got might have come up from under the banks. But that was in trout streams, where the maximum temperature existed a very short time in the middle of the afternoon, for a day or a series of days. The trout can be seen in the shady pools when the water is low and there is a high temperature. I think they instinctively seek the shade and shelter of the banks where it is cooler than the water of the stream, and they take care of themselves by leading a very inactive life during these high temperatures. We cannot look upon such temperatures as standards for the angler in applying for fish, because if

he is led to think that they can live in the higher temperatures he will want to stock with trout all of the streams where the water has become much warmer as the result of deforestation and the natural progress of civilization. Dr. Embody's experiments are very interesting, but I question whether they are practicable in hatchery work where a man is raising trout for a living or to produce large results. If the troughs in which he conducted experiments with a limited number of fish had been as crowded as the troughs at our hatcheries, the mortality would have appeared at a lower temperature.

Dr. G. C. Embody, Ithaca, N. Y.: The fact seems to be that we misjudge our streams. If only those streams in Tompkins County, New York, that did not exceed 70° F., were stocked with brook trout, there would not be more than two in the whole county. But on three consecutive days I found several brook trout there in perfect contentment with a temperature of 81° lasting for about five hours. Judging from experiments in the trough, 83° would be the maximum temperature at which trout could live perhaps for a few hours. Brook trout will live all summer in a water temperature of 70°. I would not have a bit of hesitation about going into trout culture where the water is not warmer than 74° on the hottest days. I would not expect to raise the average number of trout the first five or six years, but I would expect eventually to have a strain which would come through in a perfectly normal manner. But in a wild stream it is altogether different, because there you have not introduced conditions of domestication. Rainbow trout seem to resist the high temperature better than brown and brook trout. The last named would succumb first. I found the rainbows in higher temperatures than the browns.

Mr. Titcomb: As to propagating trout in a hatchery with a temperature of 74° or 70° for a month at a stretch, it is a proposition that I do not want to invest any money in, and I would not want the tax payers to invest any money in it.

Mr. G. C. Leach, Washington, D. C.: At Manchester, Iowa, a spring stream meanders through the meadows for quite a distance where it warms up in summer from 48° to 65° F. before reaching the hatchery grounds. We take brook trout out of the ponds and put them in the stream where they live under more or less natural conditions. During the heat of the day they congregate in pools probably five or six feet in depth, and where there is a strong current. The volume of water is probably 800 to 1,000 gallons a minute. I seriously doubt if we would be able to hold these trout in the stream successfully with a volume as small as 150 or 200 gallons per minute. We got from 85 to 90 per cent fertilization from the trout eggs obtained from the creek as against 50 per cent from trout held in the ponds at 50°. I think our success was due to the fact that the stream has a rocky bottom, deep pools, and a very large volume of water. To a certain extent we were raising wild trout. We shipped rainbow trout to Louisiana to ascertain if they would live in certain streams. The water temperature there was about 65°, and some of the fish were reported eight or ten inches in length the first year, but they never reproduced.

Mr. Titcomb: The higher the temperature in which you can successfully rear trout the more rapidly they will grow. In some hatcheries you can carry trout intensively in troughs with a temperature of 50° to 55°. At other hatcheries the water is such that you can carry them intensively at

10 degrees higher temperature. The nature of the food used in certain waters varies from that which can be successfully used in other waters. These factors are so numerous that we should try to determine what makes water suitable for carrying fish under intensive conditions. We find healthy trout in streams under natural conditions, but when we take that water to a hatchery or into pools, and try to raise fish intensively, it is with fatal results.

MR. N. R. BULLER, Harrisburg, Pa.: I would feel uneasy if I had money invested in a commercial trout hatchery where the temperature exceeded 60° for any length of time. Our greatest success in holding trout in large numbers has been in ponds where at no time has the temperature exceeded 52°. Our Corry hatchery is entirely devoted to the propagation of trout and now has at least 1,000,000 three to six inches in length awaiting distribution. I have never known the temperature there to exceed 54°. As the water comes from the earth the temperature is 46° to 47°. At the Bellefonte hatchery, where trout only are propagated, the water is from limestone springs; one of the streams flows 20,000 gallons a minute. The temperature in the ponds does not exceed 58° at any time. We have another hatchery where trout are of minor consideration as we attempt only to carry enough to supply several northeastern counties. A chance is always taken in holding them throughout the season. This year in most of the ponds the loss was due to high temperatures, which ran to about 73° as compared with a former maximum of 68°.

MR. B. O. WEBSTER, Madison, Wis.: There is no question but that many mistakes have been made in the location of stations merely by observation, because almost any cold stream will support a few trout. Conditions, however, are entirely changed when 3,000 or 4,000 fish are confined in a small space for breeding purposes. I was at the Bellefonte hatchery three years and know water conditions there. I also know the water conditions at Corry, Pennsylvania, Northville and Paris, Michigan, and at other long established hatcheries, and to my mind soft spring water is the most successful in the propagation of trout. I do not believe it is possible to propagate trout, at least to any great extent, in real hard water. A place has been finally located in western Wisconsin where I believe it will be possible to raise enough brook trout to supply the State. There we built 10 small troughs, about 18 inches wide and 10 feet long, and hatched out a lot of fish. In October after all the hot weather, 66,000 fish 4 or 5 inches long were counted from these 10 troughs. This indicates what can be done with the quality of water there. Under ordinary circumstances it would not have been possible to handle more than 4,000 or 5,000 in the space. At present we have about 200,000 to 300,000 fish there 4 to 5 inches long and the loss has been practically nothing during the whole season. The water is as soft as rain water and as clear and cool as any spring water you could expect to find. So I have come to believe that the softer the water the greater the success in raising brook trout.

MR. BULLER: At Bellefonte we propagate brook and brown trout but the brown trout did better in the limestone hard water there. We have hatcheries where the water is very soft as at Corry. We are not able to propagate brown trout there, but are very successful with brook trout. In the propagation of brook trout, if temperatures are right, the softness

of the water is of very great benefit; I also believe that brook trout are today being propagated and reared in hard water.

Mr. Webster: At our St. Croix hatchery we have about 50,000 fingerling brown trout growing as fast as the brook trout without the slightest trouble. The water there is as soft as rain water. Our success with brook trout at St. Croix is right along the line of the success at Corry, where the work has been carried on for 35 years. So far as I know the only hatcheries in the United States where brook trout operations have been conducted for 30 or 35 years without an epidemic at some time during the period, are those supplied with soft water. Mr. G. Hansen, a member of this Society, has a trout hatchery at Osceola, Wisconsin, and during the 30 years of its operation there never has been an epidemic nor have the fish ever died to any great extent. It is only seven miles from St. Croix Falls, and conditions are practically the same as at the St. Croix hatchery.

Mr. E. W. Cobb, St. Paul, Minn.: Some time ago I observed the trout at St. Croix hatchery and all that is said about those fish is true. The hatchery building is peculiar in that it has four stories. The water is very soft, while at St. Paul, 50 miles away, the water is very hard. The temperature is the same and I think our methods are the same. Our hatchery has been operated for a good many years, and, as far as I know, has never had an epidemic.

Mr. Titcomb: Our hatcheries are producing trout in both hard and soft water. We have one hatchery, established about 40 or 50 years ago, in which they raised brook trout for 30 or 35 years before they had any serious trouble with them. That is a hard water proposition now used to propagate brown and rainbow trout. I would not locate a trout hatchery under any temperature conditions without testing with an inexpensive plant for at least one year before advising the spending of any considerable sum of money, and the commissioner who recommends locating a hatchery and spending $40,000 or more before it has been tested is taking an unwarranted chance with the money of the tax payers.

Dr. Embody: My paper referred alone to the temperature of the water. Other factors such as oxygen and carbon dioxide were not considered. We know little about the effects of those other factors upon trout. We do not know how much oxygen they must have; we do not know how much carbon dioxide they can stand. Until we know the individual effects and the combined effects of these various factors, we will not be able to go to a spring and say, "This is fit or it is unfit for trout." In the present state of our knowledge, the surest way to determine whether water is suitable is to try it.

GROWTH OF FISH AND LOCATION OF HATCHERIES [1]

By John W. Titcomb

Consulting Fish Culturist
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In the past year some interesting information has developed in regard to the varying sizes of brook trout and brown trout raised at a number of different hatcheries. Briefly, the point to which attention is directed is the wide variation in size between fish of the same age reared under different conditions. The data assembled show that brook trout selected on March 1 from ten hatcheries graded all the way from the sac stage up to fish nearly 2½ inches long. Similar observations at five hatcheries in respect to brown trout, which in the earlier stages do not grow quite as rapidly as brook trout, gave a range at the same time from sac fry to good sized fingerlings. On June 1 these fish varied from about 1½ to 2¼ inches at four hatcheries, one of the plants having been closed in the spring on account of the water becoming too warm. Comparative sizes of both brook and brown trout on August 1 were also observed.

It is interesting to note the fact that on the first day of May the largest fingerlings at one hatchery cost no more than the eggs at another except the actual outlay for the food given to the former. If three-inch fingerlings can be produced by the first of May at some hatcheries, why spend money operating other hatcheries until the first of August to produce the same sized fish?

The answer seems to be largely a question of the proper location of hatcheries. Before any extensive fish-cultural work is undertaken, test stations should first be operated to see what can be done in regard to the economical development of the fish to the stage considered most desirable for planting. In connection with such tests, an important feature is to see that the fish reach the planting stage as early in the season as possible after the water has become normal, as there is then probably more natural food for their proper development and growth than two or three months later.

This matter of testing the water should not be limited to trout hatcheries. Mention may be made of a hatchery built on Lake Erie within the last four years, representing an investment of $50,000, for which establishment the water comes from a depth of about 40 feet in the lake, then passes into a deep well from the city supply

[1] This address was accompanied by a series of interesting photographs showing widely varying sizes of brook trout and brown trout at different hatcheries on the same dates.

before it is treated, and is subsequently pumped up 50 feet in the air to reach the hatchery. This water is suitable for hatching whitefish and herring, but the hatching of yellow perch and pike perch in it is practically impossible because at the time these eggs are taken in the spring the water is so cold that they will not hatch. So the investment has to lie idle at the time of year when these two important species of fish ought to be handled and could be handled in perhaps larger numbers than the herring and whitefish. The decision as to whether this hatchery should be put on a promontory adjacent to a lighthouse, or located down on the shore of the lake, was not left to the recommendation of a practical man, hence the tax payers will bear the burden for all future operation of a $50,000 plant which under the circumstances must lie idle for half of its proper life.

Mention might be made of another fish-cultural station representing an investment of about $50,000, for the propagation of bass, with an expensive pumping plant and a lot of holes in the ground on the bank of a big river where there is an entirely unsuitable water supply. Similar examples may be observed in practically every state where there are hatcheries, and include federal as well as state institutions.

This is not said to discredit any hatchery or person, but is merely brought to attention in the hope that the situation and its needs will be realized by those who may be in authority. It is hoped that when it comes to a question of locating hatcheries, advice may be sought and taken from those who have had most experience, also that proper tests of the water will be made, no matter what kind of a hatchery is proposed, before expending the people's money. Much more might be said on this subject, but it seems impressive enough when one stops to think that the public funds are being spent more or less in this unintelligent way all over the country.

Discussion.

MR. G. C. LEACH, Washington, D. C.: Mr. Titcomb spoke about feeding the fish and bringing them to No. 3 fingerlings in May, rather than later in the season. This presumably means that we first should select water in which the fish will thrive, and then feed them very heavily in order that they may grow as much as possible.

MR. J. W. TITCOMB, Albany, N. Y.: I would feed them normally, but as in suitable water they hatch so much earlier, they are fed the same length of time. The other fish are in the sac stage at a time when they are feeding, in June and July, rather than in March, April, or May.

MR. LEACH: If brook trout eggs are collected in October or November and held in suitable water, about 50° F., they will hatch probably sometime

in January or February. The yolk sac would be absorbed in possibly 30 days. I do not understand how you could force the feeding unless you gave them an extra amount of food to bring them to a large size in May. If it were possible to mingle the warmer stream water with the cold spring water, so that the temperature would be increased to 55° or 60°, possibly the rate of growth could be controlled. These things should be given consideration when selecting a site for a hatchery. If you can combine the two waters, it is possible to produce larger and better fish.

Mr. Titcomb also spoke about the necessity of testing a hatchery location. It is very easy to criticise what has been done in the past, but when a man goes out and takes the initiative in establishing a station it is a different thing. We might refer to the Holden station in Vermont which was established with a view to making it a good trout station. At that time the indications were that it would be a success, but expectations have not been realized. Another case is Northville, Michigan, which in early days was one of the leading trout stations in the United States. It produced large numbers of brook trout, and was generally conceded to be very successful but now it is given over entirely to other lines. At the Wild Rose station in Wisconsin, the water seemed to be very good for the production of brook trout eggs, but after a number of years it proved entirely unsuccessful. The Bureau of Fisheries has located a number of stations that seemed very good at the start, but later on had to be abandoned. Possibly after a station has been operated for a while improved methods in handling the fish demonstrate that at other plants better results can be secured and the station originally established has to take second rank.

Mr. Titcomb: I do not want you to get the impression that I am knocking the hatcheries generally, but our ideas in regard to them are different from 30 years ago. Many advances have been made and we have to produce more fish now than then. I located the Holden hatchery. It was tested three years by running a small plant there, keeping the eggs through the winter, and the fish in the spring; the hatchery is on one of the most famous trout streams in southern Vermont and derives its water supply from that stream and from springs. I hope that talks of this kind will be read by other than the practical men who are here, and that they will take warning. The men who have made these mistakes and are trying to profit by them are telling their experiences so that others may avoid similar difficulties. Some of the hatcheries which do not meet the present day standards might just as well be abandoned and the money put to more practical use.

Mr. Leach: I did not intend any criticism in regard to Mr. Titcomb's talk, nor wish to make any suggestion that even appears that way. He is one of the most eminent and practical fish culturists that we have today, and I believe his judgment was good in locating Holden. I meant to say that more modern methods have developed other means of making a station efficient. One may be very careful in locating a station, but later developments may show it not as suitable as was expected. The Holden station is not worthless, but natural causes have reduced its efficiency, though when established it might have been 100 per cent efficient.

Mr. Carlos Avery, St. Paul, Minn.: One thing we all agree upon is

that the men experienced in fish-cultural work in the different States and in the Federal Government should be accorded the right and privilege of making the selection of sites. State Legislatures and Congress have located fish hatcheries without consultation to learn what conditions are necessary, and the results in some cases have naturally been failures. These matters should be referred to some one in authority who has the necessary technical knowledge.

MR. N. R. BULLER, Harrisburg, Pa.: It is very important that the men in authority and the men who have technical knowledge of what is necessary for a successful hatchery should be the men to locate the hatcheries. What is the reason for the condition at Northville? My recollection is that when Frank N. Clark was superintendent it was known as a heavy producer of brook trout. What has occurred that has now made it unsuitable for brook trout?

MR. LEACH: Even though a hatchery is established where conditions appear 100 per cent perfect, later years may indicate the unwisdom of continuing operations along past lines. Northville was very important at one time. Possibly unfavorable chemical qualities of the water have developed somewhat or possibly the long years of producing brook trout have contaminated the surroundings in some way and rendered it impossible to continue with past success. Possibly newer methods in other fields will produce the eggs at much less cost for help and for food used to maintain the brood stock. All of these are contributing factors in reducing the efficiency of any station.

DR. D. L. BELDING, Hingham, Mass.: I am very glad that Mr. Titcomb has sounded a note of warning, because I do not believe that one, two, or even several years with a small experimental station will absolutely determine whether a hatchery will prove an ultimate success, although I realize that it is the best and in fact the only evidence we can get. Mr. Titcomb's paper might warrant the conclusion that we should select the hatchery that turned out the larger fish. At the present time our poorest Massachusetts hatchery is turning out the largest fish. I feel sure that Mr. Titcomb will agree that there are other more important factors in the selection of a hatchery than the rapid production of large fish.

MR. TITCOMB: One phase of the Northville situation is the expectation of doing things on a bigger scale today than when the station was established. There are a number of old hatcheries that cannot be criticised along the lines that I have been criticising.

One of the hatcheries in New York is supplied with water from the bottom of the lake, 40 feet deep. That hatchery is all right. It has both surface water from the lake and deep water. All we need there is a little money to put in new pipe lines and get more water than we have. The fish will then develop more rapidly than they do today. At another hatchery, which is on Long Island, the artesian wells and springs have a temperature of 52° the year round. If you can get your fish to come on so as to feed them in April, or even have them feeding well in May, you are going to bring them out in good season; but if there is six months of winter, twice as much labor in picking over the eggs will be necessary and there will be an abnormal loss.

DR. BELDING: Were these trout hatched from eggs from the same source

and time of taking, and were they fed at different states of development in the same manner or with the same food at the different hatcheries, so that there would be no variation in the method of handling other than difference in the water supply at the various hatcheries?

MR. TITCOMB: The fish were fed on pork or beef liver, or both, and at one hatchery after feeding liver for a time they were largely fed on eggs from suckers. I like to make a practice of buying eggs from as many commercial hatcheries as possible, and if I secure 1,000,000 eggs of one hatchery I put them at five or six different hatcheries, and when I secure enough from one hatchery I divide them up among all the hatcheries. The result is that each foreman has eggs from three to six hatcheries. Sometimes the eggs of one hatchery go bad. If each foreman loses heavily of eggs coming from any one commercial hatchery, I assume that the trouble is at the source of supply, and the next season no purchase is made from the hatchery where I got the poor eggs. I rate all of the eggs from the commercial hatcheries as shown by results at each station. This is well worth while; also the commercial men like to have the data.

MR. LEACH: Mr. Titcomb, I understand you attribute the growth of the trout to both the water supply and the food? Is it your opinion that hog liver is a very suitable food for young trout?

MR. TITCOMB: Yes, but I want to give them something else once in a while to get the best results.

MR. LEACH: Recent experience at our hatcheries has not indicated that hog liver is as suitable as sheep liver or beef liver. At most of our stations the opinion is that beef heart is far superior to either. Its cost varies at some places more and other places less, but it probably produces larger fish with less loss.

MR. TITCOMB: We have been rather limited in the expenditure for food. Our appropriation for food when the war started was the same as before the war, and there were times during the war when we carried our stock and increased them to fingerlings on less money than was spent for food before the war, and at the increased prices, because we then resorted to melts and natural food like suckers, carp, and sucker eggs. I want to correct one statement here about the food. At the hatchery on Chautauqua Lake which was located for the propagation of muskellunge, there are some artesian wells, with which we raised fingerling trout very similar to these nice large fingerlings. After the fish reach a length of 1½ to 2 inches they are fed almost entirely on the flesh of carp caught in the lake. The trout have been fed for three months at a stretch on carp, ground up the same as liver. The fish are skinned and boned; only about one-third is really good flesh but it is excellent fish food. The time is coming when the largest hatcheries are going to have their own cold storage plants and buy some sort of fish as food for raising fish. On Lake Erie thousands of small herring killed in the nets are thrown away and often the ling. They would make a mighty good change in diet from liver and that sort of thing. Occasionally opportunity occurs to buy a ton or so of butterfish in New York for one or two cents a pound, the use of which would be made possible by cold storage. Of course, there is quite a little waste, but for the larger fish you can grind up the whole thing and do not have to dress them at all.

FRESH WATER CRUSTACEA AS FOOD FOR YOUNG FISHES[1]

By William Converse Kendall

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Some years ago a number of species of small crustaceans were recommended as natural food for artificially-raised young fishes, particularly salmon and trout. The claim was made that the ease with which certain species of these little animals could be kept and bred made them particularly valuable for fish-cultural purposes; and it was also suggested that natural streams and ponds deficient in food could be stocked with this kind of food, since some species were so common and of such wide distribution that a supply was, as a rule, conveniently available. The principal advocates of the growing of crustaceans were European fish-culturists. In this country the idea had its supporters, although there were others who had no faith in it. The latter took the ground that while the culture of crustaceans as food for young fishes was practicable in European establishments, where small numbers of fish are raised, it would be impossible to maintain a sufficient supply for such food requirements in this country, where the business is conducted on a much larger scale.

In general the method of procedure was to stock adjacent ponds with crustaceans and the necessary water plants. In some instances young fish were admitted to one inclosure while another was developing. When the first pond was depleted the fish were admitted to the second, and the first allowed to be repopulated. In other cases the procedure was simply rationing out the crustaceans to the fish in their own ponds, either by dipping or admitting through troughs or pipes. The crustaceans to which particular attention was given were Daphnia and shrimp (Amphipoda). It should be noted, however, that the method of raising them did not usually admit of pure cultures of any one form, so that the stated results are affected by a certain element of error.

It is not the purpose of the present paper to discuss the relative

[1] The subject matter of this paper is more fully covered by the author's contribution under the same title and issued as Bureau of Fisheries Document No. 914, or appendix I of the report of U. S. Commissioner of Fisheries for 1922. It discusses the distribution, habits, and life histories of the most common forms of fresh water crustaceans, such as the fairy shrimps, water fleas, copepods, ostracods, isopods, amphipods, Mysis, prawns, and crayfishes. The document also treats of the possibilities of successful crustacean culture.

value of different forms of crustaceans as food for young fishes, but, assuming that those available are desirable, to indicate whether or not, other things being equal, it would be practicable to raise them in sufficient quantities to feed large numbers of young fish.

Inasmuch as crustaceans vary greatly in size, as do the fish which subsist upon them, it would first be necessary to supply to fry such sizes as they can swallow, and larger sizes to the fish as they increase in growth. While there are many kinds and sizes of crustaceans, most of which are natural fish foods, only certain very common forms have been utilized, although several have been recommended. The kinds that have been indicated in any experiment have usually been stated to be Daphnia and Cyclops for very young fish and shrimp for older fish. Daphnia and Cyclops are, as most fish-culturists know, minute crustaceans called Entomostraca. The shrimp, of which the once famous "Caledonia shrimp" was one, are amphipods or scuds. They are more suitable for fish which have passed the Entomostraca-eating stage.

The purpose of this paper is to make an analytical comparison of the stated results of experiments in crustacean culture and feeding of fish, based upon requirements according to present feeding practices at some of the stations of the Bureau of Fisheries. The particular purpose of the comparison is to prove or disprove the contention that crustaceans cannot be raised economically on a sufficiently large scale to meet the requirements in this country, granting that other conditions are equal. As concerns Entomostraca, while there are positive claims that it would be entirely feasible, there are no very definite data for comparison. The only evidence in favor indicates that after the fish attained a certain size they were fed on finely-minced horse meat instead of Daphnia.

In other connections it has been mentioned that after feeding on Daphnia six or seven weeks the fish were provided with coarser food. In this country it is customary to distribute fry at that age, so the entomostracan production would need in no instance to continue for more than that length of time. This period in the life of the fish is the most critical, and the one in which its food should be most carefully considered. It is known that young trout naturally feed upon Entomostraca when available and that the latter multiply rapidly under favorable conditions; thus it would seem that some method of raising them might easily be devised. Unfortunately in this country there have been no definitely-described experiments. It is hoped that experimental work along this line will receive early attention.

There are more definite data concerning crustacean food for young fish beyond the entomostracan-feeding stage. Some 20 or 30 years ago, fish-cultural establishments in Europe utilized the larger crustaceans, particularly the amphipods, commonly called shrimp, to a considerable extent. Over 30 years ago Consul Frank H. Mason[1] described in some detail the manner of raising shrimp for trout food at Lugrin's establishment at Gremaz, France, a famous fish farm of those days. He stated that the ponds were about 120 feet long by 12 feet wide, with a depth of 5 feet. Each pond would produce 650 to 900 pounds of shrimp in a month. These supplied 20,000 yearlings and 3,000 two-year-old fish with 20 to 25 pounds of shrimp a day, or about 600 to 800 pounds a month. It was necessary to have two ponds for each kind of fish, owing to the fact that instead of transferring the shrimp to the fish ponds it was the custom to drive the fish from one pond to another each month, so that while they were eating the stock of shrimp in one pond the other was being replenished. Two shrimp ponds would probably have been necessary for each, even if the feeding had been by transfer of the crustacaeans instead of the fish.

If the number of fish is increased, the capacity of the shrimp ponds would need to be correspondingly increased. Four ponds of the above dimensions would aggregate about one-tenth of an acre. Ponds of the necessary capacity for raising amphipods or shrimp for a given number of fish would not appear prohibitive at most large hatcheries.

It is stated that the fish fed upon nothing but the products of the shrimp ponds, upon which they thrived. To be sure the ponds contained some other organisms, but the shrimp were in greatest abundance. The fish referred to were the European trout, in this country commonly called brown trout. The question arises as to how the quantity of crustacean food in this European operation compares with that supplied to the common brook trout and the rainbow trout at our hatcheries.

At the Spearfish (S. D.) station, in the month of July, 1,000 brook trout brood fish averaging one pound in weight were fed on a mixture consisting of 93 pounds of mush and 186 pounds of liver, a total of 279 pounds. At Gremaz it required 600 to 800 pounds of shrimp to feed about 1,500 pounds of fish comprising 3,000 individuals averaging one-half pound each. At Spearfish it would have required 418.5 pounds of the combination food mentioned to feed

[1] Bull. U. S. Fish Commission, Vol. VII, 1887 (1889), pp. 203-206; and Trans. Amer. Fisheries Soc., 1892, pp. 58-77, including discussion.

1,500 pounds of fish. The mush contains little or no nutriment, but the same may be said of the shells of the shrimp. So far as the figures are concerned, however, the comparison is somewhat in favor of the mush-liver combination. On the other hand, 4,000 yearling brook trout at Spearfish were fed 372 pounds of mush and 217 pounds of liver, a total of 589 pounds. At Gremaz 20,000 trout 8 to 12 months old required 600 to 800 pounds of shrimp, which represents 30 to 40 pounds for every 1,000 fish, or 120 to 160 pounds for 4,000 fish. This throws the advantage to the crustaceans. There was probably much waste in the Spearfish feeding.

At the Springville (Utah) station 8,000 brood-stock rainbow trout averaging one pound in weight, were fed in one month 744 pounds of mush and 496 pounds of liver, or 1,240 pounds of the combination. At Gremaz it would have required 400 to 426 2/3 pounds to feed that many pounds of fish averaging one-half pound each, which suggests an advantage for Crustacea.

At the Wytheville (Va.) station 1,000 yearlings 8 to 12 inches long were fed 12 pounds a day. At Gremaz, 1,000 fish of approximately the same age were fed about 7 or 8 pounds a day, which is favorable to crustaceans. At Wytheville again, 1,000 fish 3 to 5 inches long were fed three-fourths of a pound a day. At Gremaz the daily ration per 1,000 fish of about the same age was one to 2½ pounds, which favors Wytheville feeding.

There are elements of error in these computations, but they indicate on the whole a not very great difference in the amounts fed to fish of the various sizes at Gremaz and in this country. Doubtless it would be practically impossible, if at all desirable, to provide an exclusively crustacean diet for trout of all ages. It has been demonstrated, however, that crustaceans can be cultivated in quantities; local conditions and the available crustaceans would largely determine the extent of operations. It would seem then, that a considerable collateral supply of crustacean food would be economically possible and provide a much desired variation in the kinds of food. The largest trout would require more food and perhaps greater variety. Possibly this variety could be provided by utilizing the prawn, as advocated by Worth.[1] It is probable that the prawn can be raised quite as easily as the shrimp or scuds (Amphipoda), if the conditions under which they live naturally are followed in the artificial ponds. It should always be borne in mind that all of these organisms, from the most minute to the largest, require food and that no experiment can be successful unless it is supplied.

[1] Bull. U. S. Bureau of Fisheries, Vol. XXVIII, 1908, Pt. II, pp. 853-858.

Mr. J. W. Titcomb, Albany, N. Y.: Mr. Leach, are you getting from the mush feed more than you formerly got?

Mr. G. C. Leach, Washington, D. C.: Probably less, as we are using cheaper material, shorts in place of low grade flour.

Mr. Titcomb: Do you use twice as much mush as liver, as indicated by Dr. Kendall?

Mr. Leach: For adult trout two-thirds mush and one-third liver or meat has been used at many stations where the meat cost was an item to consider. I believe one-third mush and two-thirds meat a better diet and one that will produce stronger fish. The mush, as a rule, should supply the bulk or filler. It is desirable to have some carbohydrates in the diet of the fish.

Mr. Titcomb: This is a very valuable paper, but there is one feature which Dr. Kendall does not appear to have covered. The shrimp reproduce naturally in great abundance in lime water, but there are a great many places where the trout are raised in which it is practically impossible to raise shrimp. He referred to the Caledonia shrimp, which breeds naturally in tremendous quantities in the State hatchery at Caledonia, New York, and I have found it in several other places in great numbers. It is much more abundant at certain seasons of the year. My experience is that when trout feed exclusively or very largely upon shrimp, the result is a very highly colored fish; better outside color and pinker flesh. Mr. Rowe has a natural pond at his hatchery in Maine which has produced these pink-fleshed trout and highly colored eggs. At the Caledonia hatchery some of the largest ponds have a gravel bottom and rather swift water in some portions, with quite a little vegetation in spots, and there the shrimp breed. The trout keep in splendid condition and have a very good color, not the very pink, but a much better color than the average trout fed on artificial food. I am referring to fish that weigh up to three or four pounds. We attribute the fine condition and color entirely to the amount of shrimp which they have obtained, in addition to the liver fed about once a day.

Mr. Leach: Mr. Titcomb raises the question as to the amount of flour and carbohydrates that we are putting in our fish food. We find the mush cheaper than meat and believe it essential in that it supplies carbohydrates found under natural conditions in streams. We have fed more in bulk of the cheaper grades of shorts than of low grade flour. We require many of our stations to make monthly reports of food used. One of our southern bass stations was feeding 750 adult bass $30 worth of food a year; another station was feeding about 850 fish $225 worth of food in the same period. Naturally there was a big difference in the output in favor of the station that fed the greater amount of food.

What Dr. Kendall says in regard to the feeding of shrimp would not apply to some of our southern trout stations, such as at Wytheville, Va., and White Sulphur Springs, W. Va. We cannot produce shrimp in paying quantities in the limestone water there; I refer to the Caledonia shrimp, *G. limnæus*. I believe shrimp are only produced in limestone water in the region of the glacial drifts, which seem to extend through our northern tier of States and as far west as Wyoming and Utah. At Saratoga, Wyo.,

shrimp are found naturally in very large numbers and make excellent trout food.

MR. TITCOMB: What is the prawn to which reference is made?

DR. G. C. EMBODY, Ithaca, N. Y.: It is also called the river shrimp and grows to various sizes. Those found in the Mississippi Valley are from one to one and a half inches long; they belong to two genera, Palaemon and Palaemonetes, and are warm water forms. There are many different species of Gammarid shrimps. Some of them may live in lime water, or require lime water; others do not require it. I doubt very much if you can find a clean permanent pool anywhere in the Uuited States that does not contain some kind of shrimp. They are that generally distributed. The one at Caledonia, *Gammarus limnæus*, is probably the largest, and the next in size is the *G. fasciatus*. It is very closely related to the Caledonia shrimp, but seems to prefer warmer water. It occurs along the marshes of Cayuga Lake, not only in the vegetation, but among the rocks. The Hyalella shrimps are probably not more than one-fifth as long as the Caledonia shrimp, but they occur all over.

MR. TITCOMB: Dr. Embody, have you found this common form of shrimp in sufficient abundance anywhere to think of them as possible for trout food, as we do the Caledonia shrimp?

DR. EMBODY: In suitable environment the Hyalellas are fully as abundant as are the large shrimp at Caledonia. They are much smaller, however, and easily escape notice. While they occur in both cold and warm water, they seem to multiply much more rapidly in warm water containing dense vegetation. The Hyalellas escape foraging fishes much more successfully than the larger shrimps and thus would probably hold their own much better in large natural rearing ponds such as are used for bass. The larger shrimps would probably be exterminated before they could become established. In protected inclosures not stocked with fish, however, I believe that a greater amount of fish food could be produced by using the larger forms. These might be collected and fed to the fish or the fish might be turned into forage.

MR. TITCOMB: This talk about the shrimp as a food has been up for a great many years, and the anglers' clubs have been encouraged to stock streams with shrimp to increase the food for fish. It has been a very general recommendation in the past. It is my opinion that in possibly nine cases out of ten the introduction of shrimp does not amount to anything. A great many of our streams, after being stocked, show no evidence of shrimp,—that is the large Caledonia shrimp. As Dr. Embody says, you will always find the small shrimp in limited numbers under the rocks or in the vegetation. I do not think that the introduction of the smaller shrimp in trout streams amounts to much, but there are spring-fed streams, especially in limestone formations, where the shrimp can be introduced to good advantage.

DR. EMBODY: I think that is true. The great difficulty of introducing those shrimp in many places, we found, was that the fish would exterminate in a short time the small numbers which could be introduced. It is a different matter to propagate them for fish food in protected places.

THE USE OF CERTAIN MILK WASTES IN THE PROPAGATION OF NATURAL FISH FOOD

By G. C. Embody

Cornell University, Ithaca, New York

Within the last few years there has been a notable increase in the number of commercial plants concerned in the manufacture of various milk products. These plants include mere skimming stations, cheese, butter and casein factories, and condenseries. In a great many cases they are located near important fish producing streams which constitute convenient places for the disposal of wastes. Whether the procedure in thus disposing of wastes is detrimental or otherwise to the life in the stream, depends upon a number of different factors which cannot be discussed here. It is known, however, that in many cases streams have been polluted to a degree that is very disastrous to aquatic life.

During the progress of some experiments undertaken by my colleague, Dr. P. W. Claassen, to show the effects of such wastes upon stream life, some phenomena were observed that seemed to bear directly upon the problem of growing natural food for fish. The writer was thus prompted to carry on some special work with this end in view and the following notes constitute a brief statement of certain results thus far obtained.

The experimental procedure consisted in pouring into basins of stagnant water known amounts of several different wastes. Sour skim milk and whey were the two which gave the most significant results and at the same time could be easily obtained in sufficient quantities to render their use practicable. Other wastes were tried, such as floor washings and the effluents from Imhoff tanks, septic tanks, lath filters, etc., but these were either too highly diluted or so changed as to render their use at this time impracticable.

The basins in which the experiments were run consisted of wood hatching troughs of regulation size, wood wash tubs, larger concrete rearing ponds and small ponds with earth sides and bottom. None of these basins was planted with mother organisms, either plants or animals, except for those which came in with the water at the time of filling the basins, and care was taken to eliminate all of the higher aquatic plants and predacious animals such as certain aquatic beetles, bugs, dragonfly and damselfly nymphs. Thus the only organisms started with were a few micro-organisms found in the plankton. It

may be said, however, that these materially influenced the results obtained.

The kinds and quantities of the various fish food organisms appearing in the basins varied to some extent with the type of basin and the quality of the polluting substance, and to a larger extent with the temperature of the water and the quantity of polluting substance used per unit area. These variations cannot be discussed in detail until the experiments have been concluded.

The principal food animals appearing in the basins were the following: Micro-crustacea, especially the little cladoceran, *Scapholeberis,* and the copepods, *Cyclops* and *Canthocamptus;* mosquitoes of two species; "blood worms" of the genus *Chironomus;* rat-tail maggots, larvæ of the family Syrphidæ; the common pollution worm, *Tubifex,* and mayflies of the genus *Callibaetis.*

Of these the mosquitoes, syrphid flies and mayflies were attracted to the basins for egg-laying by the odors of pollution. The micro-crustacea and pollution worms were probably introduced with the water and finding conditions suitable, multiplied to an enormous degree.

MOSQUITO LARVAE

Considering the total amount of fish food produced, the mosquito larvæ were by far the most important. The adults began laying eggs the first week in July (1920 and 1921) and continued to do so throughout the summer. In 1920 the larvæ were abundant late in September.

Of the two wastes, sour skim milk and whey, the former induced egg-laying in the shortest time and with the smallest dosage. Up to the present time the dosage giving the most promising results at Ithaca, N. Y., is as follows:

One pint of skim milk for every 10 cubic feet of water content in pond, poured in every other day for 5 days, this followed by a resting period of 4 to 6 days. In order to have a continuous supply of larvæ, the procedure is repeated after each resting period. The mean daily water temperature for this dosage should be approximately 80° F. If the temperature averages lower the period of development will be longer; if higher, it will be somewhat shorter.

In a wooden hatching trough treated in this manner there were produced 2 egg masses the second day, 6 masses on the third day, 111 on the fourth day, and an incalculable number on the fifth day, each mass consisting of a great many eggs. From the eighth to the eleventh day the basin was a wriggling mass of larvæ, many of them ready to pupate, and thus sufficiently large to be fed to trout or bass.

In this case the total period was about eleven days. On the twelfth day the basin was ready for another dose of skim milk.

In all cases where the dosage was increased beyond 1 pint per 10 cubic feet of water every other day for 5 days, there was a perceptible odor not at all agreeable. The resting period tended to prevent bad odors. If the production were undertaken on a larger scale one would presume that bad odors would be more in evidence even with the dosage mentioned above.

It was stated that two species of mosquitoes appeared abundantly in the ponds. These were *Culex sexatilis* and *C. territans*. The former is reported as not biting man but the latter is considered a pest in many places. However this may be, it can be stated positively that during the two summers that this work has been going on and many thousands of mosquitoes have been allowed to reach the adult stage, no one living or working on the hatchery grounds has been pestered by them day or night.

There is no need of allowing the mosquitoes to reach the biting stage, if they are collected and fed to fish at the proper time. It is very easy to observe the first mosquitoes reaching the pupal stage and if the pond is drawn off or if it is swept carefully with a net of fine-meshed bobbinet, the mosquitoes can be disposed of to the fish before they are ready to transform.

There are two possible advantages in using the net. One may have a fairly continuous supply of larvæ by allowing the small ones just hatched to pass through the meshes of the net. These will grow and can be captured the next few days. The other advantage is that no pollution is allowed to enter the fish pond.

Bass and trout will eat large quantities of mosquitoes with apparent relish. The rate of growth in the case of the trout seems to be as rapid as with any other food tried by us. The mosquitoes are especially useful as a supplement to those food mixtures consisting of dried meat, fish, and clam and shrimp meal. Certain health and growth-promoting substances called vitamines are absent or else occur in insufficient amounts in these meals, and consequently by their continuous and sole use food-deficiency diseases appear in trout. It has been found that when live mosquito larvæ are fed with the dry meals not only is the mortality lowered but the rate of growth is increased.

OTHER FOOD ANIMALS PRODUCED

The rat-tail maggots and tubifex worms occurred in the earth and cement ponds and in the wood troughs. They were abundant when a high dosage was used. Neither form, however, appeared in such

great numbers as was the case of the mosquitoes. The maggots seem to be preferred over the worms by trout and bass but bullheads are active eaters of pollution worms.

The larvæ of certain midges *(Chironomus)*, commonly known as blood worms, also appeared in some numbers in the polluted earth ponds. They are to be reported upon at a future time by another person.

The three forms of micro-crustacea, namely, *Scapholeberis, Cyclops* and *Canthocamptus*, appeared abundantly in earth ponds when the dosage was very light and also in heavily dosed earth ponds after the polluting materials had been largely decomposed. They persisted in rather dense cultures during the greater part of May and June and again in late July and early August. The dosage best suited for the development of these forms has not yet been determined.

Before concluding these notes it is well to state that success was attained in those ponds only which were practically water tight. Even a slight change of water, as occurred in newly built earth ponds through seepage, was enough to leach out the elements concerned in fertilizing the pond and attracting mosquitoes for the purpose of egg laying. The conditions must thus be as stagnant as it is possible to make them.

Discussion.

MR. G. C. LEACH, Washington, D. C.: Dr. Embody, have you ever experimented by placing the milk around the edges of ponds containing the fish and noting the development of the mosquitoes?

DR. EMBODY: No, we have never tried that. I do not know whether the development of the mosquitoes would be harmful at all, but if you use too much milk you may pollute the water beyond the degree of safety to the fish.

MR. LEACH: Possibly that could be determined and the proper amount put in so the development of the larvæ would not be too great and they would not get beyond control.

DR. EMBODY: Of course, you cannot control the mosquitoes in a large pond as you can in a small pond. I do not think this would work successfully in a series of very large ponds, but one could control them very nicely in a series of small ponds. By having several ponds, with the culture started at various times, you could simply have a rotation of ponds, feeding the larvæ from one while they were developing in the others.

MR. J. W. TITCOMB, Albany, N. Y.: Dr. Embody, have you considered the cost of producing this kind of food as compared with other kinds?

DR. EMBODY: No, we have not reckoned the cost of producing the food on milk waste.

MR. LEACH: If applied to the raising of young bass, a series of small

ponds could be arranged, with an opening into the main pond, and we could then raise our bass to the fingerling stage without cannibalism.

MR. C. O. HAYFORD, Hackettstown, N. J.: Dr. Embody deserves great credit in this matter. Under his direction we polluted with milk some trout ponds, measuring 5 ft. by 30 ft., and secured mosquito larvæ in such abundance that they could be dipped out by the solid quart. Our method of collection is to use a net with a large bag, the bottom of which is closed by a draw string. This is swept through the ponds, then lowered into a pail half full of water, the draw string unfastened, and the contents washed into the pail. A two-inch tea strainer is used in taking them from the pail and throwing them to the bass. Both trout and bass take them very readily. One hundred and eighteen were taken from the stomach of a bass measuring 1¾ inches. The young fish follow the larvæ through the pond, and unless they can get to such shallow water that the young bass cannot enter, every one will be taken.

Another plan would be to construct your food-producing ponds so they can be drained into the pond containing the young fish as soon as larvæ are developed. This does away with hand feeding. By covering a pond with cheesecloth to prevent the adult mosquitoes from laying more eggs, we can control the size of the larvæ. If for any reason the larvæ become so numerous that they pupate before they can be removed, a little oil poured on the water will kill them all, thus preventing an excess of adult mosquitoes.

I think the problem of raising mosquito larvæ can be worked out for each locality, and I believe that Dr. Embody has opened up a wonderful field for us all to tackle.

MR. TITCOMB: What was the size of the little bass when they took the mosquito larvæ?

MR. HAYFORD: They were about an inch to an inch and a half long, and three weeks to a month old. We have plenty of microorganisms in our waters and the bass feed upon them for about three weeks. By that time the supply is running low, and mosquito larvæ are fed. In one pond where we fed the larvæ we have about 12,000 young bass. Along one side of the pond runs a concrete wall from which we feed. After feeding for about two weeks, the young bass flock to the wall when the feeder appears and follow him the length of the entire pond, feeding on the larvæ with the same eagerness that trout display in feeding.

MR. LEACH: Do you think you can feed the mosquito larvæ and eliminate the daphnia, that is, let them take the place of the daphnia in feeding the young bass?

MR. HAYFORD: I think after the bass are two weeks old they will take the mosquito larvæ. During the first three weeks we have plenty of microcrustaceans for them to feed upon, and it is only when this supply becomes exhausted that the larvæ are necessary.

MR. LEACH: A large number of our stations do not produce daphnia and we have to depend on something else up to the feeding of artificial food stage. If the mosquito larvæ can be produced in large numbers, and the rate of growth will not be too great they can be fed to the bass up to the time they take the larger insect life.

DR. EMBODY: It is not the size of the mosquito larvæ so much as it is the time of the year in which they are produced. We are not able to produce mosquito larvæ before the first of July, and probably by that time your bass would have reached a size large enough to take even the largest mosquito. We could not produce them as early as May or June, although it may be done in some other parts of the country. The first day or two after the mosquito is hatched it is small enough for the smallest bass to eat.

MR. LEACH: We may try the experiment at some of our stations on a large scale and demonstrate its practical possibilities in regard to feeding the young bass.

MR. HAYFORD: At the New Jersey station we can secure the larvæ around the latter part of May. Under our conditions the bass do not need the food much before the 15th of June, or the 1st of July.

MR. TITCOMB: Do you know yet, Mr. Hayford, whether you will reduce cannibalism, and, if so, to what extent, by the introduction of larvæ?

MR. HAYFORD: I cannot say to what extent cannibalism will be reduced, although I am positive, from my comparison of the fish in the ponds fed with the larvœ and those not so fed, that it is reduced considerably. I also observed that in the ponds where the larvæ are fed, the young fish grow much more uniformly.

DR. EMBODY: I think that the micro-crustacea would be more important in the spring of the year than the mosquito larvæ. In all of the ponds where we used a small dosage of milk, among the first forms to appear were the little crustaceans of the genus *Scapholeberis*. They are very closely related to the daphnia, of which Mr. Leach spoke, and so small in size that the smallest fish can eat them.

SALMON EGGS AS FOOD FOR SALMON FRY[1]

By Martin Norgore

Seattle, Washington

It is exceedingly important to the fish culturist to obtain efficient and cheap food. In fact, to one who operates a hatchery on a commercial basis, success or failure depends largely on the cost of food. For a long time it has been known that fresh food is necessary at certain intervals to prevent undue, if not complete, mortality. But as long as food was valued on a calorie basis only, the reason for this requirement in hatcheries was not known. In the light of what is now known concerning the role of vitamines in the diet, however, many curious phenomena occurring in hatcheries may be explained. It is now well established that protein, carbohydrates, fats, and mineral salts are not sufficient to keep an animal in healthy condition and make it grow. There are certain properties called accessory food substances, or vitamines, which the food must possess. At least three of these have been recognized on the basis of their solubilities, namely, (a) fat soluble, or growth promoting; (b) water soluble, or antineurotic, and (c) water soluble, or antiscorbutic.

It need hardly be mentioned that as yet little is known concerning vitamines. But it seems that certain of them are destroyed by heating, salting, or drying at high temperatures. The fat soluble is the most stable, while the water solubles are more easily destroyed. Little is known about the effect of low temperature on the accessory food substances, but it seems that cold storage foods retain the vitamines if kept properly and not too long.

Since the early days of fish culture, liver, melts, and kidneys have been used to supply the fresh food requirements of the fish. But it happens that at present these meats are expensive and often difficult to obtain. Consequently, if a substitute could be found which is cheaper and contains all the necessary vitamines, fish could be produced at a lower cost. Successful efforts have been made to substitute, in part, other products for liver or melts. Dr. G. C. Embody has found that trout will keep well and grow on a diet of meat, fish, or shrimp meals for six days, and liver on the seventh. In some hatcheries canned salmon and liver have been used with good results. But no successful attempt has been made, so far as the author is aware, to dispense with meats altogether.

[1] Results of some experiments carried on in the experimental hatchery at the College of Fisheries; University of Washington, Seattle, Wash., and published with the permission of Mr. John N. Cobb, Director of the College.

The experiments herein recorded were initiated to determine if cold storage salmon eggs contain the accessory food substances for salmon fry. Salmon roe was chosen because it is cheap and easily available at the canneries and cold storages on the Pacific Coast, where it constitutes part of the refuse. The eggs used were taken from chum salmon *(Oncorhynchus keta)* in November, 1920, and kept in cold storage during the winter. The lowest temperature to which they were subjected was —4° F. at the time of freezing and 10° F. during storage. In addition to these, fresh roe of chinook salmon *(O. tschawytscha)* was used in four quantitative experiments. To be sure, the use of salmon eggs as food for fry is not new, but heretofore the eggs have been cooked, thus necessitating the use of fresh meat, such as liver or melts, to supply the necessary vitamines.

The eggs were obtained from the cold storage, allowed to thaw out, ground in a meat grinder, and strained through a coarse cloth to remove the shells. The last operation was found necessary in the quantitative work to insure complete consumption. The substance was then absorbed with wheat middlings, making a mixture of 80 per cent salmon eggs and 20 per cent middlings. In this way, the ground salmon eggs were made available to the fry.

The water used during the first part of the experiments was pumped from Lake Washington, at Seattle, into a large settling tank from which it was drawn for the hatchery. But occasionally the water in the tank became low and some sediment passed through. Fearing that this would affect the results of the experiments, city water was turned on in the hatchery on May 14, 1921. No appreciable change in the quantitative work was observed. Seattle city water is no doubt purer than the water used in many hatcheries.

On March 24, 1921, two lots of 125 each of chinook salmon fry *(O. tschawytscha)*, four months old, were placed in two troughs of equal size. The fry had been starved for four days, previous to which they were fed on the fry of small redfish *(O. nerka)*. All were in the same condition. The rate of water flow in both troughs was the same, about 166 gallons per minute. The inside measurements of the trough were 82 x 14 x 6 inches. The space to which the fry were confined is 26½ x 14 x 4 inches, or a capacity of 1,484 cubic inches of water. The light was regulated by means of shades to approximately the same intensity throughout the trough.

One of these lots was fed exclusively on canned salmon. This was considered the control, for it is known that the antiscorbutic and antineurotic vitamines are easily destroyed by heat. It was therefore expected that this lot would die in time, due to the lack of these

most important food substances. The other lot was fed on canned salmon for four days and on the mixture of ground salmon eggs and middlings for three days alternately. This was deemed sufficient to determine whether cold storage salmon eggs would prevent the "deficiency diseases."

Both lots grew at about equal rates and nothing out of the ordinary was observed until June 11, when some of the fry which had received canned salmon only assumed a vertical or semi-vertical position, elevating the heads out of water. On June 14 one of this lot died. No further deaths occurred until June 21, when the experiment had to be terminated. But fungus developed on more than half of them, while those that were still apparently healthy had frayed pectoral fins. The abnormal behavior persisted throughout. The other lot which had received as part of its rations the salmon eggs and wheat middlings mixture were all in perfect condition when the experiment was terminated.

Quantitative experiments were undertaken to determine the efficiency of salmon eggs as a flesh producer or growth-promoting food. Troughs of the same size as in the experiment already described were used with the same flow of water. And the space to which each lot was confined was of the same dimensions. At the beginning and end of each experiment, the fry were weighed in water on regular laboratory balances, according to the method employed by Embody. In all cases about 20 hours elapsed between the time of the last feeding and weighing. Each lot was fed twice daily. To eliminate waste, the fry were taught to take the food as soon as it reached the water. By means of a pin, pieces sufficiently small for one "bite" were carved out and dropped into the trough. Fifty chinook salmon fry and 100 chum salmon fry were used in each experiment, lasting seven days. In all 24 experiments were completed over a period of 49 days, the most important results of which will be found in the following table:

RESULTS OF QUANTITATIVE EXPERIMENTS WITH SALMON EGGS AS FOOD FOR YOUNG FISH

[The percentages of daily consumption and of daily growth are computed on the basis of initial weights. There was no mortality.]

Species.	Age in months.	Average temperature. °F.	Percentage daily consumption.	Percentage daily growth.	Efficiency factor.	Food.
O. tschawytscha	5½	50.7	2.6	2.1	80.61	Cold storage eggs.
Do..........	6	54.3	3.42	2.39	70.5	Do.
Do..........	6½	57.5	4.71	3.44	72.9	Do.
Do..........	7	59.5	4.52	2.56	57.7	Fresh eggs.
O. keta........	3	59.4	5.34	3.81	71.71	Cold storage eggs.

From the above data it appears that the food value of salmon eggs is extremely high. And the rate of growth is, in the opinion of the author, above normal. Special attention is called to the results obtained when fresh eggs were used. These were taken from chinook salmon during the first week of June, 1921, and were not by far as well developed as those used in the other experiments. On the basis of our knowledge of vitamines, the explanation seems to be that the riper the egg the more growth-promoting substance it contains. But as only four series of experiments were completed with these eggs, too narrow conclusions must not be drawn. Nevertheless it is interesting to find that the percentage of daily growth of the same lots of fry dropped from an average of 3.44 to 2.56 and the efficiency factor from 72.9 to 57.7, with practically the same percentage of food.

It is not yet demonstrated that cold-storage salmon eggs contain all the food requirements of salmon fry. The experiment inaugurated to determine this had to be terminated prematurely. But the results indicate that salmon eggs are a cheap and efficient substitute for fresh meats in the hatcheries, especially on the Pacific Coast. For promoting growth they appear to be the best food ever tried. The author suggests that fish culturists who are within reach of a supply of salmon eggs try them out as a substitute for liver or melts on a limited number of fry, using liver as a control. In this manner no undue risk is assumed.

Discussion.

DR. G. C. EMBODY, Ithaca, N. Y.: The food situation on the Pacific coast differs from that here. It is very difficult for those rather isolated western hatcheries to get the more expensive liver, yet it has been found that some such fresh food must be used. Canned salmon has been fed largely but it happens that this food can be fed continuously for a few days only, depending on local conditions, without producing certain diseases. In order to prevent those diseases, the fish must be fed upon fresh liver or some substitute.

MR. G. C. LEACH, Washington, D. C.: This paper shows some very painstaking investigations, and brings out most interesting information, especially as to the necessity of feeding a well balanced diet. I was wondering as to the advisability, however, of feeding fresh salmon eggs, except in case of emergency. I believe no mention was made of feeding unfertile eggs.

DR. EMBODY: These are all unfertile eggs. They are waste from the canneries and are ordinarily thrown away.

MR. LEACH: The protein content of fish eggs is very low, about 15 per cent in the herring. At some of our Pacific stations we once fed canned herring roe without success, and as this paper goes on to show,

after it is fed a while there are certain indications that the fish will not thrive on it. In fact, the young sockeye salmon will not take the canned herring roe, unless they are absolutely forced to do so; but if the roe is cooked and mixed with other food they take more kindly to it. As to the vitamines, I understand cooking the food would destroy them and, for that reason, I do not think that cooked salmon eggs would be of much advantage. The paper is very interesting and brings out some things that will be of much value to fish culturists, especially on the Pacific coast.

Dr. Embody: Here is a waste product that is being dumped into Puget Sound by the ton; a little is sold to fishermen, but the greater part is wasted. Liver is expensive and hard to get out there; it costs more than in the East, but here is a fresh product, presumably an ideal food, with absolutely all of the elements for the young fish, because it contains the yolk upon which the young fish grow in the early part of their existence. Working upon this as the first thought, the author was inspired to run these experiments on a fresh material. Now as you cook the eggs you destroy those growth-promoting substances called vitamines. Probably the chief reason why this food has not been used fresh before is because the eggs are too large for the young fish to eat, and when run through a grinder, the material inside is in such a fluid condition that the fish cannot consume it, as it dissolves in the water. So it was mixed with wheat middlings, thus being put in solid form, and by feeding it to the fish excellent growth resulted. A very high percentage of the material is actually consumed and made over into fish flesh.

FURTHER PROOF OF THE PARENT STREAM THEORY

By Alexander Robertson

Harrison Hot Springs, British Columbia

Considerable attention has been paid by fish culturists to the so-called parent stream theory, that is, the assumption that anadromous fish return to the stream in which they were bred, to reproduce their species. In the course of time the consensus of opinion was that the salmon of the larger rivers, such as the Columbia and Fraser, certainly returned to these rivers, and the controversy narrowed down to whether the fish returned to the individual tributary in which they were hatched. By scale readings of the Pacific Coast salmon Dr. Charles H. Gilbert came to the conclusion that they returned to the actual creek in which they were bred. Further light on the subject, by one who has made a study of it on the spawning grounds for nearly twenty years, may be of interest to those engaged in fish culture.

Ever since the first hatchery was built on the Fraser River it has been common knowledge among hatcherymen that the runs of sockeye salmon to its various tributaries differed in many ways, chief among which was the time of arrival at the spawning grounds. The latter could be depended upon to such an extent that one crew of spawntakers could operate several stations, one after another, from September to January, with no variation in the sequence from year to year.

Another characteristic, and one which as far as the writer is aware has never been given much prominence, is that the difference in the size of the sockeye eggs at the different creeks has been so apparent and constant in the course of time as to pass without comment.

In 1914 the writer began a series of measurements of sockeye eggs taken at Morris Creek, Harrison Rapids, and Cultus Lake, which has been continued each year since. Morris Creek enters Harrison River two miles above the rapids and Cultus Lake lies twelve miles southwest. The three stations are thus comparatively close together, which fact adds interest to the subject.

To obviate the inaccuracies of imperfect chambering such as occurs when a graduated glass or similar measure is used, a new method of measurement was devised. A light V-trough one meter in length was set up at an inclination of twenty-five degrees and the eggs allowed to roll down until the trough was filled from end to end with

one row of eggs, the figures appearing in the tables herewith being the number of eggs required to fill the trough. As far as the exigencies of the regular hatchery work permitted, the eggs were measured twenty-four hours after spawning and from three to five counts were made during the season.

SERIES OF YEARLY MEASUREMENTS OF SOCKEYE SALMON EGGS

Year.	Morris Creek.	Harrison Rapids.	Cultus Lake.
1914	166.0	152.0	182.0
1915	162.8	150.0	183.0
1916	164.0	153.2	181.3
1917	166.7	149.8	185.2
1918	163.0	153.5	185.5
1919	162.6	150.0	184.0
1920	165.4	151.6	182.6
Average	164.3	151.4	183.3

The uniformity from year to year is very evident and the fact that the figures for one locality never overlap or even approach those of another shows that there is a distinctive species of sockeye at each of these places.

Another interesting phase is that the size of the egg does not correspond with the size of the fish or the time of spawning, for the smallest fish of the three, that from Harrison Rapids, has much the larger egg, as will be seen from the following table which shows the length in inches, dates of spawning, and average measurement of eggs:

VARIATION IN SPAWNING SEASON AND SIZE OF SOCKEYE SALMON EGGS

Locality.	Males.	Females.	Spawning season.	Number of eggs to meter.
Morris Creek . .	26.3	23.9	Sept. 25—Nov. 15	164.3
Harrison Rapids	23.6	23.1	Oct. 25—Dec. 10	151.4
Cultus Lake . .	25.3	23.2	Nov. 15—Jan. 1	183.3

That the size of the egg is not due to fuller development in the later spawning fish is shown by the fact that the Cultus Lake sockeye, the last to spawn, has, as far as the writer is aware, the smallest egg of all the Pacific Coast sockeyes.

A summary of the whole subject shows that at Morris Creek there is a run of large, early-spawning sockeyes with medium sized eggs; at Harrison Rapids very small, late-spawning sockeyes with very large eggs, while at Cultus Lake there are also small, late-spawning fish with exceptionally small eggs.

Discussion.

Mr. Ward T. Bower, Washington, D. C.: The method of measuring eggs referred to is not unlike that devised by Mr. Hector von Bayer, formerly architect and engineer of the Bureau of Fisheries, which was reported fully in a publication of the Bureau. It would seem that the same principle is involved. Years ago in my experience at the station at Battle Creek, California, where we handled in one season more than 57,000,000 chinook salmon eggs, it was well known that their average size varied considerably through the season. Several times during the continuance of operations very careful counts of the eggs were made a few hours after they were taken, and a variation of 200 to 300 eggs per quart would be found, the eggs increasing slowly in size as the period of incubation advanced.

Dr. G. C. Embody, Ithaca, N. Y.: The claim made in this paper is that because the eggs do not vary in size in one particular stream, those eggs came from parents that were hatched there and have returned to that same stream, and that since there is a variation in the three different streams, each having a different size of egg, each must have been produced by parents that were hatched there. Mr. Robertson does not indicate here which of the three streams was entered first by the fish, but he says that the larger size of the egg is not due to fuller development in the later spawning fish, for apparently the sockeye which spawns latest in the season has the smallest egg of all of the Pacific coast sockeyes.

Mr. G. C. Leach, Washington, D. C.: I do not believe that sockeye eggs vary in size as do brook trout eggs, where we find a variation of possibly 300 per ounce. Yes Bay, Alaska, has a run of sockeye salmon that enters the lake along in July, begins to spawn about the first of September, and continues until along in January. There is a considerable variation in the size of the eggs between the first spawners and those later in the season. The cannerymen in Alaska know the number of salmon from a particular stream required to fill a case, and that this average per case varies little from year to year. I believe it is generally conceded that there is some slight variation in the size of the eggs.

Dr. D. L. Belding, Hingham, Mass.: This paper is especially valuable in adding one more bit of presumptive evidence in favor of the parent stream theory. I do not believe that we can say absolutely that the measurement of eggs alone proves the parent stream theory, but it certainly offers strong circumstantial evidence. There is little doubt that the alewife or branch herring returns to a particular river to spawn. When there are several branches with separate spawning ponds, there is some question whether fish return to the identical pond where they were hatched. That this specializing tendency exists has been shown by creating fisheries through planting adult alewives in unfrequented waters to which they return for spawning in three or four years. However, there is also evidence that they do not always return to these particular ponds.

In 1920 a fishway was installed at the Lawrence dam on the Merrimac River, which for years had formed an impassable barrier to fish. Alewives had spawned in certain tributaries and even in the river below the dam, when they could not get to the spawning ponds, and they now ran

up this new fishway into regions where they had never been before. Thus there is evidence that though the alewife comes back to a definite spawning ground, it will also seek new territory.

MR. W. E. BARBER, Madison, Wis.: The parent fish stream theory is not nearly as hard to understand and believe as that the migratory birds after traveling thousands of miles come back to their home nests. It is true that demonstrations as to the migratory birds are easily made. Strict account has been kept of their flights, and it has been found that they cover the same territory and come back to the same nest each year.

MR. TITCOMB: Dr. Belding's remarks on the alewife remind me of the introduction of shad on the Pacific coast in California. Most of them probably return to the stream where first planted, but they have spread gradually until they are up in the Columbia River. I am not combatting this parent stream theory, but the shad spreading on the Pacific coast seem to furnish an example to the contrary.

MR. BOWER: Perhaps it should be made clear that Mr. Titcomb does not challenge the parent stream theory with respect to the Pacific salmon. He has gone beyond that and has spoken of fishes to which the parent stream theory has never been applied so far as I am aware. Shad were introduced on the Pacific coast in the seventies and have spread widely. I personally have seen shad in Alaska of the same species that I have noted in the Potomac River in the East. The parent stream theory has never been entertained, so far as I am aware, in regard to shad; but I believe that it is the consensus of opinion that the Pacific salmon return to the parent stream. Dr. Charles H. Gilbert, of Stanford University, California, the greatest authority on the Pacific salmon today, has demonstrated clearly that they undoubtedly return to the parent stream, and moreover, that they seek the particular side tributary where they were originally hatched or planted. Dr. Gilbert bases his conclusions chiefly upon a study of the scales of the salmon, thus securing a most accurate life history of the fish.

SOME OBSERVATIONS ON THE GROWTH OF YOUNG SOCKEYES[1]

By Alexander Robertson

Harrison Hot Springs, British Columbia

The depletion of the sockeye salmon is the most serious problem confronting the fishing industry of the Pacific Coast of America, and fish-cultural methods in connection therewith are very much in the limelight at the present time. Provided that a sufficient number of adult sockeyes are allowed to pass to the spawning grounds, which may probably mean a complete cessation of sockeye fishing for a number of years, authorities all agree that increased protection during the early life of the species is the remedy for the situation, but considerable diversity of opinion exists as to how this is to be accomplished.

Under ordinary circumstances, sockeyes remain in fresh water for at least one year, but whether it is a rigid law of nature or merely an expedient to attain a certain size before meeting the destructive competition of the sea, it is hard to say. Anyway, it is conceded that in certain cases, notably that of the Harrison Rapids sockeye of the Fraser River, certain of them do proceed to sea as fry and that particular race of sockeyes does not appear to have suffered depletion any more than others with a stream-type of fish.

That the stay of sockeyes in fresh water appears to be a matter of choice, received some confirmation last year through an experiment at Grace Lake, a small barren body of water at the headwaters of Morris Creek, near here. About one hundred thousand fry were planted in that lake in April, 1920, and during July and August of the same year, the majority of the fingerlings left voluntarily for the sea when they had attained a length of three inches. These fish were not over six months old and the result of an abundance of natural food, coupled with freedom from molestation, is plainly evident in the fine appearance of the fish. Though conditions were seemingly ideal for a lengthier stay in the lake the fish left of their own accord, thus strengthening the presumption that size is probably a determining factor in the migration of the sockeye. At that time it was supposed that all the fingerlings had left, but this year several thousand fingerlings came down, our attention being first attracted by their appearance in the settling tank of a small hatchery installed below the lake. Fry planted at the same time in Otter Lake in an adjoining barren body of water, all left the first summer, slightly smaller than those from Grace Lake, probably owing to the water being colder.

[1] This paper was accompanied by a number of interesting specimens of young salmon.

One and a half million fry have been planted in these lakes this year (1921) and the outlets have been screened to control their departure.

In June, 1920, sockeyes were planted in Hicks Lake, an originally barren lake lying at an altitude of 500 feet, three miles east of Harrison Lake Hatchery. No migration occurred the first summer. The outlet at the lake is shallow and weedy and doubt was expressed as to whether the fish would find it. A close watch was kept and on May 5 we were agreeably surprised to find the creek swarming with yearling sockeyes, and the run continued to the 19th when it ceased as decisively as it had commenced. As there are two falls with a combined height of 100 feet in Hicks Creek, which drains the lake, a flume 500 feet long, three to five feet wide, and two feet deep, was constructed of split cedar to provide a safe descent for the migrating fish. The first fish to come down were eight inches long and the length gradually decreased to five inches as the migration progressed. This again demonstrates that the size of the fish is a factor in the seaward migration, as the largest fish were the most anxious to leave this lake, which has an area of about 400 acres and a depth of 200 feet.

A heavy run of these seaward migrating natural yearling sockeyes occurred from Cultus Lake in April of this year then, the average length being only three inches. The diminutive size of these yearlings indicates a shortage of food, and shows that the feeding capacity of the lake was severely taxed to feed them in addition to the permanent fish life of the lake.

The time-worn assertion of Fraser River fishermen that small fish at the beginning of a fishing season is an indication of a big run of fish thus receives corroboration, for it is quite reasonable to presume that in nature the more numerous the fish the less food each individual will receive. Incidentally, 30,000 of these fish were marked by removing the adipose and right ventral fins, to try to settle the much-debated question as to whether the Cultus Lake sockeyes enter the Fraser River during or after the regular fishing season.

Natural sockeye yearlings were also collected from Cultus Lake in 1919, when there was a very small migration due to a poor run in 1918. The average size of these fish, however, is fully an inch larger than those taken in 1920, corroborating the foregoing statement in regard to food supply.

The sockeyes reared in the ponds at Harrison Lake Hatchery at six months old were four inches in length and were fed four months, first on the bodies of the parent fish and later on chum salmon, liver,

and maggots. Most of the credit for this rapid growth is due to the good start the fry got on this food, some of them attaining a length of over two inches on it alone; the fry showing the most partiality for it were the healthiest and most contented in the ponds. It appeared, however, that this food is suitable only for the earlier stage of fry life, as milk is to the young of animals, for later on they ignored it entirely.

In a paper[1] read at the Annual Meeting of the American Fisheries Society two years ago, the writer described how sockeye fry ate the bodies of their parents when preserved in cold water through the winter.

Spring or king salmon fingerlings five to six inches in length when six months old, were fed four months on chum salmon, liver and maggots. The remarkable growth of these fish and the sockeyes just referred to inclines one to question the necessity for holding the fish over to the second summer, especially when comparing them with the natural yearlings from Cultus Lake.

The question is, does the sockeye remain in fresh water merely to attain a certain size, and, provided that size has been attained in six months instead of a year, are its chances of survival any less? If they attain a year's growth in six months, will they return a year sooner? An attempt to throw some light on these questions was made here this year by marking 4,000 six-months-old and 8,000 yearling sockeyes with distinctive marks to see when they will return.

The food on which the fish were fed was placed on submerged trays a foot under water and suspended from floats. A lump of ground salmon and liver, mixed with a little gravel if it showed a tendency to float, was placed on each tray several times a day and the fish soon learned to nibble it off. Fed this way the fish got more substance from the food, and there was less waste, than if it had been cast on the surface in a liquid state.

With large, deep ponds, water between fifty and sixty degrees in temperature, and plenty of raw fish and liver, it is a comparatively easy matter to rear sockeyes to a length of three or four inches in six months. The feeding of millions of fry and fingerlings is an expensive undertaking, and the mortality is bound to be high where fish are crowded and unnatural food is fed; thus a number of years will elapse before facilities can be provided to rear all the fry under these conditions.

By utilizing the barren lakes, meaning natural ponds and lakes

[1] Robertson, Alexander: The parent fish as a food supply. Transactions of American Fisheries Society, Vol. XLVIII, June, 1919, pp. 158-9.

utterly devoid of fish life because of falls in their outlets, accommodation is immediately available for large numbers of fry, feeding is not necessary, and there appears to be no mortality worth mention. The strongest argument against the use of these lakes is that some of the fish may refuse to leave and consequently prey on the fry subsequently planted. This is assuming that the same lakes are used year after year, which, of course, is optional, but even if some do remain and subsequent plantings are made, one has the callous satisfaction of knowing that sockeyes are being fed to sockeyes and not to trout, chubs, squawfish, and sculpins, as has been done heretofore.

The stocking of these lakes, which are more or less remote and difficult to get at, was done in the following manner: A trail was made and the eggs, on the point of hatching, were carried to the lake in a specially made back-pack holding 50,000. The eggs were then placed in hatching trays, one layer deep, and two trays thus loaded, with an empty one on top for a cover, were securely fastened together. This stack was then placed in a small spring tributary with rocks underneath the corners to keep it off the bottom and more on top to keep it down, and left there until the fry were free-swimming. Every week or two these were inspected, and at the proper time the fry were released.

Discussion.

DR. E. E. PRINCE, Ottawa, Canada: It may be interesting to those of you who do not know the Pacific rivers very well to learn that 20 to 30 years ago the Fraser produced the sockeye or red salmon in probably greater abundance than any other known river. These salmon proceeded to the upper waters of the Fraser, 500 miles upstream. Other schools proceeded to nearer spawning grounds, within 50 or 60 or 100 miles; thus there was a succession of schools of sockeyes from June until October, even sometimes into November. As the result of a very serious condition, the upper spawning grounds of the Fraser were cut off for some years, and the earlier runs were practically destroyed. This was the primary cause of the decline of the stream. It is generally recognized that the sockeye salmon spawn in streams tributary to a lake which itself empties into the main river. The Fraser River illustrates the life history of the sockeye to a remarkable degree. It really is not a very large river; but it has immense spawning areas. Now, the question arises as to whether the size to which the sockeye attains before it begins to descend is due to this distance from the sea and to the fact that the food is inadequate for such immense numbers of fish in the upper waters.

MR. G. C. LEACH, Washington, D. C.: One of the important sockeye salmon stations of the Bureau of Fisheries is at Yes Bay, Alaska, producing in a good season from 60,000,000 to 70,000,000 eggs. It is located at the head of Lake McDonald which is about five miles in length and connected with the ocean by a small stream about 3 miles long. The young

salmon placed in Lake McDonald, after the yolk sac is absorbed or after a short feeding period, leave the lake in large numbers when about three inches in length the following May or June, approximately a year later. The young fish have been fed some with salted salmon, also with fresh Dolly Varden trout. They are usually fed from one to three months, after which they seek their own food. In the spring of the year the young salmon are found around the edges of the lake devouring the remains of the parent fish. For this reason it is believed that when the food becomes scarce in the lake they usually run out into the sea.

Mr. Robertson refers to planting sockeye eggs in more or less barren lakes and inaccessible waters. About two years ago this was tried at Yes Bay. The eyed eggs were planted in the gravel of the lakes or streams and hatched under natural conditions. If we stock the barren lakes, and the fish can reach the sea, it will mean the protection of the young fish from Dolly Varden trout and other enemies which do not reach such waters. Such plants must be given careful study and the number to be planted must be based upon stream conditions, food and the chances of survival. I believe eyed eggs should be planted within ten days or a week of the hatching period and no attempt made to cover them up if in a flowing stream. If in a lake, 1,000 eggs or so placed on a hatching tray set on coarse gravel and covered would be preferable.

Dr. G. C. Embody, Ithaca, N. Y.: It is generally believed on the Pacific coast, and supported by very good evidence, that the sockeye, together with its near relative the little landlocked red salmon, does not compete with other salmons and trouts for food, their principal food being microscopic crustaceans. I saw a number of stomachs which were in the possession of Dr. Victor Smith at the University of Washington, and in all of these there was a mass of entomostraca. I noticed no other forms whatever. All were microscopic organisms. These fish were adults, while the little red salmon were from 10 to 16 inches long. I also saw some stomachs taken from larger sockeyes which contained entomostraca. As I remember, they were two or three years old. I do not know whether it was due to a preference for that food or scarcity of other natural foods. I think Dr. C. H. Gilbert makes the statement that the gill rakers are a little longer and more closely set than in other salmon. That would indicate they were capable of straining out finer food. Seeing those salmon full of these small crustaceans indicates to me their preference for such food.

Mr. Arthur Merrill, Sutton, Mass.: I would like to inquire as to the survival of the young sockeye salmon sent by the Government to Pennsylvania and Maryland this spring. They were about four inches long. Last week I learned that some had been caught there with hook and line 10½ inches in length. I should like to know whether in the opinion of Mr. Leach they will survive?

Mr. Leach: The Bureau of Fisheries does not make any attempt to stock eastern waters with sockeye salmon. The fish mentioned by Mr. Merrill were from eggs sent to Central Station, Washington, D. C., for exhibition. It is my opinion that a few may survive and reach maturity, but I doubt if they will reproduce and maintain themselves on the eastern seaboard. It is a different story with the humpback salmon. In the fall of 1916, 4,000,000 eyed eggs were shipped from the Pacific Coast to the

hatchery at Craig Brook, Me., and in the following spring 3,900,000 fingerlings were planted in Dennys River. In the fall of 1919 the Craig Brook station collected approximately 500,000 eggs from these salmon which had returned to spawn. They ranged from five to six pounds in weight.

MR. MERRILL: In Massachusetts waters only the chinook is handled. So far as concerns the work on the Merrimac River, there have been no results at all. We have had varying results in the ponds. Some ponds, for a brief period, gave very good results, but we had the same experience as in other places. After a brief period of very interesting fishing, it fell off to practically nothing. The work has been discontinued. The fish were planted as fingerlings, varying in age from three to six months.

MR. LEACH: I understand the Massachusetts Commission endeavored to establish Pacific salmon in their streams and landlocked lakes, and that those in the lakes reached very good size, but never reproduced. It is important to know if the species will maintain itself in such an environment. Is there on record any instance of the chinook salmon reproducing in those lakes?

MR. MERRILL: There is no instance of reproduction in the lakes of the State, but at the Sandwich station the fish matured and spawned and the resulting fry grew to fingerlings. This was accomplished last year under artificial conditions.

SOME FISH-CULTURAL NOTES, WITH SPECIAL REFERENCE TO PATHOLOGICAL PROBLEMS

By Charles O. Hayford

Superintendent, State Fish Hatchery, Hackettstown, N. J.

A fish culturist, operating on a large scale, is confronted with many problems, but he also has many remedies in his own back yard with which to combat these difficulties. In the summer of 1919 the Fish and Game Commission of New Jersey set aside a small sum of money to be used for experimental purposes, as directed by the writer, for overcoming certain difficulties which it was believed could be corrected. Investigations have been conducted by Dr. George C. Embody, assisted by Frederick Tresselt, and Professor W. T. Foster, assisted by Robert W. Hodgson. A brief resumé of some of these investigations follows.

FEEDING AND DISEASES OF TROUT

Experiments were carried on during the summer of 1920 to determine the value of the various artificial and natural foods used for trout at the Hackettstown Hatchery. These experiments clearly demonstrate the value of natural food in the diet of hatchery trout together with the relative importance of the artificial food combinations.[1]

The production of the greatest possible number of fish through the elimination of all factors detrimental to the increase of the same, is the object of every fish culturist. To accomplish this, a careful investigation of each of these factors is necessary. The greatest reduction in the number of fish, under hatchery conditions, is brought about by disease. Each individual hatchery has its own problems, although more or less general conditions prevail throughout. In this hatchery we have been confronted with two important diseases, one protozoan and the other bacterial. The protozoan disease, namely, *Ichthyophthirius multifilis,* was present during the seasons previous to 1920. It affected the rainbow trout. This is not recognized as a serious trouble, in view of the fact that a very specific cure is known, and once the diagnosis is made, the disease can be eliminated.

The case is somewhat different with the other disease, which is more or less common throughout the country. It is of bacterial origin and is characterized by the development of gray spots on the head in the region of the cerebral hemispheres, followed by an appar-

[1] Transactions, American Fisheries Society, Vol. L, pp. 251-256, 1920.

ent loss of balance, causing a spiral whirling. Death generally occurs shortly after this stage is reached. The fish affected are those in their first year, from May to September, which for the Hatckettstown hatchery would mean fish from 1½ to 4 inches in length. Both brook and brown trout were affected, but the brook trout to a greater extent.

The two possible sources of this organism are the water and the food. In view of the fact that this disease, as far as known, is not present among fish in the native streams, the possibility of the transmission of the organism by water may be eliminated. The examinations of the various foods such as beef liver and sheep plucks show the presence of organisms not unlike those isolated from the diseased fish. The study of these organisms has not been carried on to a sufficient extent to show that they are identical, but it suggests a possible relationship. It was thought that the presence of dissolved gases such as CO^2 and O might be looked upon as a very important contributing factor in the loss of fish in the hatchery, but a series of experiments carried on in the laboratory has shown this factor is negligible. No noticeable difference appeared between equal numbers of fish held in two ponds, one showing a maximum of CO^2 and the other its absence.

The substitution of natural food such as Asellus and maggots for artificial food, as beef liver, was the next logical step. Since, under natural conditions, the fish subsist entirely on insect food, it appears that there must be a certain something, such as a vitamine, which is present in the natural food and lacking in the artificial. This vital substance apparently has an inhibitory effect upon the offending organism within the body of the fish. Experiments have shown that when the disease appears in the hatchery a change of diet to natural food has checked its further progress. On the return to the previous food, immunity continues for from four to five weeks or more. This has been worked out with both brown and brook trout but more especially with the brook trout. Some aquatic insects seem to possess greater germicidal properties, while another type of insect food possesses greater nutritive value. A combination of two, when more scientifically worked out, may solve the problem of loss of fish by this disease, as was indicated by feeding experiments carried on during the summer of 1920. The whole problem narrows down to one of diet, but without doubt the diet would have to be modified as required by the conditions at the different hatcheries. Each fish culturist would therefore have to work out his specific salvation based on his own conditions, but according to general facts.

Stomach examinations of young bass carried on at the Hackettstown station show that during the first few weeks of their existence their food consists almost entirely of microcrustacea, the predominating organisms in their order of importance being Cyclops, Simocephalus, Chydorus and Scapholeberis. These forms can all be produced in the rearing ponds, and by the time the quantity of smaller organisms has been reduced the fish will have attained a sufficient size to take large organisms and will prefer them as food. It is at this time that the supply should be supplemented by the daily introduction of some form of natural food which is abundant and easy to secure.

At this station we have fed the following organisms with good results, all of which we can produce in quantities large enough to be of importance:

Abbott's minnow *(Notropis chalybaeus abbotti)*
Larva of the Mayfly *(Callibaetis culex)*
Larva of the Culex mosquito
Maggot of the flesh-fly
Water boatman, or Corixa
Fresh-water sow-bug, or Asellus.

All of these organisms are most abundant during the months of June, July, and August, during which period they are also in greatest demand by the bass culturist. While they are all utilized to some extent, certain of the organisms are more acceptable to the fish and are taken more readily than others. The mosquito and Mayfly larvæ and the small minnows are the forms most eagerly taken, while the maggots and young sow-bugs are rejected at first but taken readily enough when the young bass become accustomed to them. The Corixa is taken readily by the larger fingerling bass. By the use of these natural foods we find the bass can be trained to feed at a certain spot with the same avidity as do trout. Experiments are now being conducted to ascertain the possibility of rearing the fresh-water shrimp *(Gammarus fasciatus)* in large enough quantities to be of importance as a food for the young bass.

Discussion.

Mr. C. O. Hayford, Hackettstown, N. J.: At the Hackettstown hatchery we have 164 trout ponds arranged in 17 separate parallel lines and all are fed by spring water. They contain brook, brown and rainbow trout, existing under identical conditions, and yet the mortality will vary widely. The mortality record for the day may show one pond to be normal, a loss of 40 in a second, 25 in a third, and 50 in a fourth. The reason for this wide variation when the ponds and the fish are identical in all respects

and are handled the same, is one of the problems we are attempting to solve.

Generally speaking, we can correct excess mortality by substituting for meat such natural insect foods as fly maggots, the larva of the Culex mosquito, and the fresh-water sow bug. I would like to emphasize the fact that when the meat diet is stopped and natural food is substituted the affected fish live a great deal longer and a large proportion of them recover. Three or four other hatcheries have obtained practically the same results. It is noticeable that when we place affected fish in natural streams where they secure insect food a large proportion immediately recover.

We have found that fish flesh and intestines are more attractive to flies than other flesh, such as sheep liver and lungs, and that, if the weather conditions are the same, a given amount of flesh distributed in numerous small quantities over a large area will produce more maggots than the same amount placed in one spot. The mosquito larvæ are secured by pond fertilization with skimmed milk, according to the method which Dr. Embody has explained in a paper at this meeting. The sow bug or Asellus is developed in a stream which is choked with water cress and *Elodea canadensis*, and which receives the washings and waste water from the trout ponds. It is estimated that 100 bushels of these bugs were secured from this stream during the summer of 1921. About 150 tons of fish food of all kinds is used at the hatchery each year. A daily record of the mortality of each individual pond is charted and a glance shows when the mortality of any particular pond is rising. One instance of the value of our chart method was a spring fed pond which supplied some trout ponds, but the water did not produce the same results as were secured by using water from other spring fed ponds. This year the spring was enlarged and deepened, and aquatic plants and insects were placed in the ponds, which now are among our most successful for raising trout.

Mr. G. C. Leach, Washington, D. C.: Do I understand that the parasite *Ichthyopthirius* has given you considerable trouble at Hackettstown?

Mr. Hayford: No, it has not. Most of our water has a temperature of about 50°, at which the parasite causes no trouble. Rainbow trout, however, need a temperature of from 60° to 65° and at this temperature the disease becomes serious. We have found a method of eradication which consists simply of placing the affected fish in a pond with a strong flow of water. Since the parasite must leave the body of the fish to propagate, it is at once swept away by the water. The ponds from which the fish have been taken are treated with a one per cent solution of milk lime. We have always been able to confine this trouble to one pond, and since the foregoing method was tried have had no further outbreaks.

Mr. Leach: In our aquarium at Washington we have trouble with the parasite *Ichthyopthirius* every spring, when the temperature of the river water gets above 50° F. At that temperature or below the growth of the parasite is arrested. The trouble continues until the temperature rises to about 65°, and then it disappears. We have never treated fish with a lime solution, though we have tried common baking soda. We put the fish in a trough containing about as strong a solution of the soda as

they will stand. A saturated solution of soda is then applied with a paint brush to both sides of the fish, which is immediately thereafter put in the weaker solution of soda. This is very effective in killing the parasites, although difficult to do because they will bury themselves in the mucous membrane.

Dr. D. L. Belding, Hingham, Mass.: The subject of fish disease is important to the fish culturist because the ultimate and continued success of a hatchery depends in a large measure upon freedom from disease. Fish are subject to diseases of various kinds: nutritional, developmental, parasitic, and bacterial, not to mention mechanical injury, e.g., water pollution. With the exception of a few protozoans, crustaceans, and worms, the parasitic diseases are of minor importance. The fish culturist is chiefly concerned with the bacterial diseases, especially the epidemics which at times threaten to ruin completely his hatchery. I believe that the work of Mr. Hayford, Dr. Foster and Dr. Embody, looking toward the prevention of disease by building up the resistance of the fish by means of proper environment, natural food, and selective breeding, is a most important step towards the prevention of disease in our hatcheries. However, steps must also be taken to combat disease directly, since the virulence of the invading organism, as well as the resistance of the fish, must be considered. If you can eliminate the organism or reduce its virulence, you will solve the problem.

In the summer of 1920, at one of the Massachusetts state hatcheries, we lost our entire stock of fingerling and adult brook trout, owing to an epidemic of the disease commonly known as "Furunculosis," which is caused by a pleomorphic bacillus. Possibly six writers in Europe and the United States have described organisms so similar that I believe we have to deal with a general group, the individual members of which differ in virulence, in type of lesions, and in certain other characteristics. The disease which became epidemic during the summer months first broke out in the previous December, but caused slight mortality during the cold weather. As the temperature of the water taken from a 10-acre pond rose above 55° F., the number of deaths began to increase, and by the time it had reached 60° F. the disease had become epidemic, spreading from pool to pool, until all the fish were infected. At the height of the epidemic, a death rate of 500 adults per day was attained. If we had been able to keep the temperature of the water below 55° F., this particular disease could never have assumed epidemic proportions. The chances of having epidemics are considerably lessened when the temperature of the water at a hatchery is less than 55° F., even though cold water itself will not entirely eliminate disease. As a rule, the warmer the water, the more difficult is the control of an epidemic, owing to the lowered resistance of the fish and the maximum growing temperature for the bacteria. To illustrate, in Furunculosis, at 57° F., it takes five days to kill inoculated fish, while at 65° F., similarly treated fish die in two days.

While I shall confine my remarks to only one bacterial disease, Furunculosis, the same general principles hold true for all bacterial diseases. Furunculosis is spread chiefly from fish to fish by direct contact,

but it may be transmitted through the water. Subcutaneous injections of bacteria are almost invariably fatal, but feeding either material from the lesion or cultures of the bacteria causes few deaths. Evidently the fish do not invariably acquire the disease when exposed to bacterial infection unless there is a local lesion or a point of lowered resistance. Therefore, continued contact with diseased fish is an important means of spreading the disease. The artificial condition of hatchery rearing favors the tendency to keep the maximum number of fish per pool. The fish receive unnatural food and do not get exercise as in nature. Thus, the chances for catching the disease and the spreading of an epidemic are very much greater among hatchery fish. The only practical treatment is radical elimination by killing the infected and exposed fish and thoroughly sterilizing the pools. Early diagnosis and prompt action are necessary to check bacterial diseases. Radical methods offer the only efficient method of handling such epidemic diseases.

In hatchery work the prevention of disease, not the treatment of individual fish, is the prime essential, except in the case of valuable aquarium fish. Mechanical or chemical methods of treatment are of little or no value for the septicæmic diseases. With the exception of the beneficial effect upon fungus of the salt, and possibly the mud, bath all the empirical methods handed down from the dark ages of fish culture are valueless in combatting bacterial epidemics, and frequently do more harm than good. In treating fish infected with Furunculosis, I have tried every method I had ever heard of, and the untreated fish lived longer than the treated, probably due to the additional handling. In my opinion, we have all been laboring under a delusion, as regards the efficiency of the bath and the chemical treatment of bacterial diseases of fish.

MR. J. W. TITCOMB, Albany, N. Y.: Were the fish in water above the pools?

DR. BELDING: They were in separate pools fed chiefly by springs, but were unfortunately contaminated by implements used in the diseased pools, a condition which could have been avoided if rigid isolation had been enforced. To illustrate the practicability of absolute isolation in this connection, it may be stated that this particular hatchery had two divisions—one at Sandwich, and the other at East Sandwich—three miles apart, and that, by instituting a rigid quarantine, the Sandwich division was kept entirely free from disease. I believe we could have quarantined those fingerlings, although it would be more difficult because of proximity, seepage from contaminated ground, and fish-eating birds. This spring the disease was checked by promptly destroying 600 fish in one pool where infection was discovered. That is a debatable question. At the time, I decided that it was better to kill the fish in order to keep Massachusetts waters absolutely free from this disease. Since then, I have found diseased wild fish, indicating that Massachusetts is not free from this particular disease, although possibly it is less prevalent than in New York, New Jersey, and Pennsylvania. Now, I would be inclined to recommend that these fish be put into some coastal streams of limited range and the results watched. Of the 600 fish referred to probably less than 10 per cent would be infected, and they would spread over a comparatively wide territory. It is probable that the 10 per cent would die without

infecting the others, and even possible that the diseased fish might recover, though in the hatchery I have never seen any fish recover from the disease, nor have I noted any immunity among the survivors of an epidemic.

MR. TITCOMB: Is it not true in most instances where there are diseased fish that if you liberate them when not too far gone so they have natural conditions and a free run, a large proportion of them will recover?

DR. BELDING: If we are not contaminating new waters the thing to do is to put out the fish and let nature take its course. I do not know the origin of that disease but it has been found in 25 rivers in Bavaria, and in this country is prevalent in New Jersey and New York. It is not limited to the trout or salmon family, since many salt and fresh water species are susceptible to artificial inoculation. I have not found this disease in salt water fish, under natural conditions, but believe it may exist. Circumstantial evidence indicates that this epidemic was started by feeding whiting. Low vitality would render the fish more susceptible to the disease, but I believe that the strongest hatchery trout would in time succumb to this virulent disease. For instance, the landlocked salmon are more, and rainbow trout less, susceptible than the brook trout. Both the rainbow trout and the brown trout are more resistant to disease generally.

MR. TITCOMB: We might say that all our trout, under these intensive conditions which are not quite normal, would naturally be more susceptible than they would be in wild waters.

DR. BELDING: Naturally, the disease would spread by contact infection more easily at the hatcheries. About 40 per cent of the diseased fish show local lesions in the form of external abscesses and ulcers. The peritoneum is also affected in certain cases and a thin bloody fluid exudes from the vent. In crowded pools other fish are constantly in contact with this infectious material. So far as I know no animals except fish are susceptible to this particular disease which evidently spreads through the water from fish to fish and occurs in the wild state. It is possible that at some time this was a harmless bacterium which later acquired pathogenic properties for fish. The bacterium which we isolated at the Sandwich hatchery was first called *Bacterium salmonicida* in 1894 by Emmerich and Weibel in Bavaria, and *Bacterium truttæ* in 1904 by Marsh in the United States.

MR. TITCOMB: Do you think this disease can be connected with pollution?

DR. BELDING: I do not. The earlier investigators believed it was due to water polluted with organic materials from barnyards, not the chemical trade waste pollution of today, but later observations have completely disproved this idea.

MR. J. M. CRAMPTON, New Haven, Conn.: At our hatchery last spring we had 100,000 two-inch trout which died at the rate of about 10,000 a day until all were gone. Their eyes were protruding and they were transparent. The water temperature was 56° F. and Professor Rutger of Yale University said it was as fine as any spring water he had examined. Those who furnished the liver and melts fed to the fish declared them fit for table use. The minute we put the fish into another spring, or tank from another spring, they died more quickly than those held in the original trough. We salted the springs and did everything we could think of to save them, but they all died in about 10 days. I have since heard that there is not a State

in the Union but has had these same epidemics. There is an excavation which runs directly down to the head of the spring, and we had imagined that oiling the road had polluted the water; but Professor Rutger says there was absolutely nothing of the kind there.

DR. W. T. FOSTER, Easton, Pa.: The only water ever found without organisms was from an artesian well. Water may be pure for drinking purposes and yet have organisms in it, and it still may affect fish, though not human beings.

DR. G. C. EMBODY, Ithaca, N. Y.: Can any of these scientists tell us what the chances are of carrying this disease from one hatchery to another in eggs or in the package used in shipping eggs?

DR. BELDING: I do not know. Diseases undoubtedly vary as regards transmission through eggs. In this particular disease you might be able to get uncontaminated eggs, since the majority of fish stripped would not be infected even if the disease were present among the brood stock. If fish with infected body cavities were stripped, the eggs would be directly contaminated. Whether such eggs kept in running water would be thoroughly cleansed of bacteria before the fry were hatched is at present unknown. In this connection I seriously question the advisability of using raw fish as food in hatcheries, owing to the danger of transmitting bacterial and parasitic diseases. Pasteurizing or even bringing the food to a boil would completely elimate this danger, but feeding raw fish will always be a potential source of danger.

MR. TITCOMB: Is there more danger of transmitting the disease from fish than there is from liver?

DR. BELDING: Fish infections are probably different from mammalian diseases, and by using diseased fish for food you would expose your fish to diseases to which they were susceptible, whereas they probably would not be infected by diseased mammalian food. Cold storage liver in the course of handling might pick up a disease bacterium that would affect your fish, but the chances of producing any fish disease except nutritional or toxic disturbances are very slight.

MR. LEACH: Do you believe that these bacterial diseases would be injurious to human beings?

DR. BELDING: The causative organism of Furunculosis is not injurious because it will not grow at human body temperature.

MR. LEACH: Most of the fish fed to fish in the Mississippi Valley are of the coarse species found there and are not considered of best quality for human consumption. I think they would be very free from any such disease. I think the same condition applies on the Atlantic Coast, except that the herring and other fish which would be fed might be too stale for the market. I do not see how they would contain such germs, especially since they are from salt water.

DR. BELDING: I am convinced that this disease is prevalent among salt water fish and that it can be transmitted by feeding diseased fish to trout. Definite proof upon this point is lacking, but Mr. Keil in his paper of yesterday mentioned cases where, in his experience, this particular disease followed feeding fish food, and in the records of the United States Bureau of Fisheries there is also a description of a similar case. Thus

presumptive evidence, at least, suggests that there is a possible association between feeding fish as food and this disease.

MR. N. R. BULLER, Harrisburg, Pa.: The bacterial disease referred to by Dr. Belding and Mr. Hayford is not new. Going back 30 years I know of a hatchery in Pennsylvania where an epidemic of this kind occurred. It is not always in high temperatures that the disease prevails, for here the maximum in the ponds was only 50° F. Drastic action was taken, every fish being killed and the ponds emptied and thoroughly sterilized. The hatchery is in operation today and since that time there has been no trouble from the disease. I would hesitate to believe that this particular disease can be transferred in the eggs, for the reason that we have hatched many that came from stations where it was present, without any apparent development of the disease.

MR. LEACH: I never heard of the disease at our western stations where we take eggs from wild fish. It has only occurred at such stations as are supplied with eggs from commercial hatcheries, and I thought possibly it was due to the lowering of the vitality of those fish.

MR. CARLOS AVERY, St. Paul, Minn.: I would like to know the opinion of these scientific men as to whether fish from wild streams would not be more liable to such diseases than healthy domesticated fishes, and whether immunity might be built up in these domesticated fishes, the same as in other animals?

DR. G. C. EMBODY, Ithaca, N. Y.: At times during the last three years I have been working with Mr. Hayford in an effort to develop in trout a resistance to certain bacterial diseases. The results thus far are very promising, but we believe it will take six years, at least, to bring them to a point where we will be able to deduce any permanent conclusions. So far our experiments indicate a practical explanation of what happened in the case of the breeders at a certain hatchery. I am not sure that it was a bacterial disease there, but it was some kind of disease, and the presumption is that it was bacterial. At any rate the trout that were right below the basin which was so badly infected, did not take the disease. I understand, from what Dr. Belding said, that this disease rarely occurs in wild trout, that he found very few cases among the wild trout. Is that true?

DR. BELDING: I have never found it in wild trout, but have cited it in two pickerel from different ponds in Massachusetts. It has been reported in wild salmon and trout in Ireland and in a number of rivers in Bavaria. I also understand that it is present in wild fish in New York, New Jersey and Pennsylvania and is especially prevalent in certain private preserves.

DR. EMBODY: At any rate it is not so prevalent among wild fish as among hatchery fish, and in my opinion it is distinctly a disease of domestication. We have diseases of domestication in the history of our poultry breeding. If you take wild jungle fowl, from which all of our poultry are supposed to have come, and put them in a chicken coop and try to raise them like ordinary chickens, I am sure you would not raise very many. They are susceptible to the diseases of domestication. Our domestic poultry are resistant to those diseases. It has taken hundreds of years to bring that about through unconscious selection at a time when nothing was known about selective breeding. Something is known about that now and I believe we are justified in attempting to produce disease-resistant trout.

There are two ways in which the disease may probably be prevented; one is by feeding a little natural food, as Mr. Hayford has done with some satisfactory results, and the other is by developing a disease-resistant strain. Undoubtedly the quickest way to get rid of the disease is to destroy all the infected fish, but that is not a permanent way. As was mentioned in one case, the disease came back again in two years. I do not care how many ponds of fish you destroy, the disease is bound to return again, unless you develop a resistance in your fishes. I do not know how far this may be carried out, but if the results continue to pile up, I am sure that you will be greatly surprised when the experiments are finally concluded.

FISH PATHOLOGY

By W. T. Foster

Easton, Pennsylvania

Early in the summer of 1920 the writer was called to the State fish hatchery at Hackettstown, N. J., for the purpose of carrying on some experiments in fish pathology, with special reference to the bacterial diseases of fish. But a comparatively small amount of work has been done along these lines, especially in the United States. The only investigator who has done much work along the line of fish diseases in general is Hofer of Germany, whose book, "Das Handbuch der Fisch Krankheiten," has not yet been translated into English.

Most diseases among fish are caused by plant and animal micro and macro organisms. Comparatively little is known concerning the diseases caused by the microscopic vegetable organisms or bacteria. Bacteria are microscopic plants comprising a subdivision of the fungi. The two more important diseases with which we have come in contact at the hatchery, and which are more or less universal, are those caused on the one hand by a microscopic animal and on the other by a microscopic plant. The first mentioned disease is caused by an infusorian of the protozoan group known as the *Ichthyophthirius multifilis*. It is comparatively easy to detect this organism by the presence of small, grayish, pimple-like protuberances on the bodies of the fish. By scraping off one of these and placing it under the microscope the actively moving organism can be seen, thus substantiating the naked eye diagnosis.

A specific cure for this disease is known, and, therefore, should not receive our serious attention. It is a matter of keeping our eyes open, and once the disease is detected in its incipiency, the therapeutic measure is simple. This disease is fully discussed elsewhere. With the bacterial diseases the case is quite different. A number of diseases of this type have been fully described; the organisms causing them have been isolated and classified, but the eradication of these diseases when once they appear creates a difficult problem which is not easy to solve.

The one bacterial organism with which we come in contact perhaps more than any other and which creates more varied morbid conditions in fish, is that described by Marsh, formerly of the U. S. Bureau of Fisheries, and known as the "Bacterium truttæ." At the hatchery we have isolated what we believe to be the same organism, from the heart's blood and from local lesions. The disease as we

have found it exhibits itself in a very peculiar but very definite way. It occurs mainly among two to three inch brook trout fingerlings. The first manifestation is the development of gray spots in the region or directly over the cerebral hemispheres, the spots increasing in size and finally running together. About this time the fish begins to gyrate in a more or less spiral fashion, which movements always, as far as observed, end in death. At the hatchery we have termed this disease the "whirling sickness" or the "cerebral spot disease." In every instance the organism in great numbers has been isolated from the local lesions and the heart's blood. This organism has been shown by Marsh to be of a pleomorphic type, that is, it exhibits different forms under different conditions. The writer believes that a number of diseases may be caused by different strains of this organism in somewhat the same sense that we have different strains of the Pneumococci and typhoid bacilli. Dr. David L. Belding, of Massachusetts, has been confronted with what appears to be the same organism, producing in the adult brook trout ulcers which usually prove fatal. We have begun a comparison of these organisms with the belief that there is close relationship between the two.

In making attempts to combat this disease, after learning the morphological and cultural characteristics of the organism, the plan was to ascertain the source and mode of infection. Attention was then directed to the water supply and the food. The food used at the Hackettstown hatchery consists of butterfish, beef liver, pork melts, and sheep plucks. Samples from different lots of this food taken from cold storage were examined, and organisms not unlike those above described were isolated from the sheep hearts and the beef livers. It was not possible to carry out the work sufficiently to prove that the organisms were normal to the beef and sheep, as these animals are warm blooded, while fish are cold blooded. It is quite possible for an organism of this type to gain access to the food mentioned on being handled.

The lactic acid bacillus is not present in milk while in the udder nor is it introduced into the milk intentionally, but always gains access on subsequent handling. If the food is proved to be a carrier of the organism, sterilization would eliminate it. If the water is the agent of transmission, the destruction of the bacteria would be a difficult problem in view of the fact that any germicide now recognized for the treatment of water would have a very harmful effect on the fish. On the other hand, the organisms isolated from the heart's blood and from the local lesions in the fish have proved to be very resistant to germicidal agents. In laboratory experiments these bac-

teria have been placed in an iodine solution directly on a microscopic slide and the organisms continued their activities, apparently unaffected in the slightest degree.

The same was true in the case where local lesions were treated with this solution, the organisms showing no effect of the germicide. The preparation of a vaccine or an antitoxin, although proved to be effective, would be out of the question because of the impossibility of application due to the size and number of the fish that would require the treatment.

In the above investigations the work has not been carried far enough to prove anything definitely, and the results of our observations are given simply as food for thought, with the feeling that others may be sufficiently interested to carry on further experiments, eventually of great value to fish culture.

But in view of all these facts, the writer is of the firm opinion that the diseases that prove to be the most disastrous are those of bacterial origin, and, owing to their nature, mode of transmission, and apparent resistance to recognized germicidal agents, can only be controlled by the creation or rather development of an immune strain of fish. Fish in the native streams as far as we know are immune to these diseases. This immunity has been developed naturally and there is no reason why this condition among fish in our hatcheries cannot be developed artificially by subjecting them to the disease in question and breeding from the survivors of each succeeding generation. In view of the present facts this seems to be the only solution of the problem.

BACTERIOLOGICAL ANALYSIS OF AN EXPERIMENTAL PACK OF CANNED SALMON[1]

By Reginald H. Fiedler

Seattle, Washington

It is well known that bacteria cause spoilage of canned salmon. At the present time there is much agitation on the part of salmon canners to determine just how long to process salmon in order to kill any bacteria present. When it is remembered that the annual production of canned salmon on the Pacific Coast exceeds 7,000,000 cases, we find the question of grave importance. It requires a longer time to kill certain bacteria than others, as for instance spore-bearing bacteria will withstand a longer process than non-spore-bearing bacteria. The purpose of this investigation will be to determine the length of time and the temperature of the process necessary to kill certain spore-forming bacteria inoculated in the cans before processing.

HISTORY

Much literature has accumulated in the past quarter of a century in regard to the bacteriology of canned foods. However, very little of this scientific investigation touched upon the bacteriology of canned salmon. To throw some light on the present experiment it may be of value to give a short résumé of previous efforts along this line.

The first scientific work in the bacteriology of fisheries products in this country was conducted in 1897 by Prescott and Underwood, who studied the spoilage of canned salmon and lobsters. They separated several species of bacteria from the samples studied. Inoculation with these brought results. They tested retort and water-bath sterilization and found the former to be the better method.

In 1908 Cathcart, of the Lister Institute, made examination of "blown" sardines. A health officer had rejected these cans as unfit for food. Upon opening, the cans gave off a very violent smelling gas. Organisms of the *B. coli* type were isolated. Feeding these cultures to guinea pigs proved negative.

Teyxeria, 1910, in Italy, investigated the cause of poisoning thought to be due to spoiled canned fish. He found several kinds of

[1] This experiment was undertaken as a problem in the College of Fisheries, University of Washington. The bacteriological work was carried on in the bacteriological laboratory of the University, under the personal supervision of Dr. John Weinzirl, head of the Department, to whom the author is indebted for advice.
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bacteria present, including *B. prodigiosus, B. botulinus, B. enteritidis,* and two molds of minor importance, indicating serious underprocessing, leaky cans, or contamination of cultures.

In 1911 Sammet studied different kinds of fish put up in cans in various ways. He found some of those preserved in vinegar spoiled and had acetic bacteria present, also spore formers of the mesentericus group were present. In salted fish, such as anchovies, he

While working for the Bureau of Chemistry, Mrs. Obst exam-
found micrococci and, rarely, bacteria of the mesentericus group.
ined sardines and isolated a spore former resembling, if not identical with, *B. walfischrauschbrand* (Nielson). Sadler of Canada isolated bacteria from canned sardines. In examination of the cottonseed oil used, no bacteria were isolated.

Dr. Weinzirl, in 1918, studied canned salmon and found two out of 17 cans contained living bacteria, or other organisms. He also found the colon group prevailing in canned sardines. Since the intestines are not removed from the fish it may be that the bacteria there present survive the processing. This group causes the can to swell and spoils the fish as well.

In 1919, Hunter and Thom examined 537 cans of salmon and found 237, or 44.7 per cent, contained living organisms, in one form or another. The high prevalence of non-sterile cans might in part be due to the class of canned goods inspected. They confined their investigations largely to canned salmon rejected by the Quartermaster Corps. They isolated a peculiar spore former that has a tendency to redden the meat of salmon and whose spores resisted a considerable degree of heat.

In the National Canners' Association laboratory, Bagley Hall, University of Washington, Seattle, 1920, Dr. C. R. Fellers, Mr. R. W. Clough, and Mr. O. E. Shostrom found in over 200 normal commercial packs of salmon an average of 7.2 per cent of non-sterile cans. In suspected packs this percentage was much higher. In an experimental pack of canned salmon prepared in the same laboratory, only 4 per cent were found non-sterile. The fish were canned in one-half pound flat cans and were processed 80 minutes at 240° F.

DESCRIPTION OF EXPERIMENT

Cultures used. Cultures were obtained from the bacteriology department, University of Washington, and subcultures were streaked on agar petri plates, these plates being used because they have a large surface upon which to get an abundant growth. In all cases the subcultures were allowed to incubate not less than three days. This gave ample time for the formation of spores. Spore-forming bac-

teria were used. This type of organism is more resistant to heat and thus would be of more practical value in the experiment. It is also found the greatest number of times in canned salmon. The following bacteria were used: *B. albolactus, B. vulgatus, B. mycoides, B. sporogenes, B. botulinus, B. cereus, B. pseudotetanicus,* Hunter and Thom's bacillus *(B. mesentericus, Flugge),* a thermophile, and soil from the street.

Canning. White king salmon were obtained from local wholesale fish dealers, which had been caught in the waters of Alaska by trollers, iced, and then shipped to Seattle. At the time of canning, the fish were at least a week old, and perhaps older, but as they had been kept at a comparatively low temperature they were in very good condition. All the canning was done in the canning laboratory of the College of Fisheries, University of Washington, Seattle. After being thoroughly cleaned, heads removed as well as fins and viscera, the fish were hand packed in one-half pound flat sanitary salmon cans.

Inoculation of cans. In inoculating the cans a short wire was smeared over the cuture prepared and thrust into the meat as near the center of the can as possible. Reasonable care was taken to ward off any contamination. Eighty-eight cans were filled and inoculated, 40 cans on April 8 and 48 cans May 13, 1921. As a control, 8 of the latter, two for each temperature, were not inoculated. Each kind of bacteria was inoculated in eight different cans. All the cans were then exhausted for 15 minutes at 212° F. with the top on loosely (clinched). After exhausting they were double-seamed and processed, two of each inoculation for 45 minutes, two for 60 minutes, two for 75 minutes, and two for 90 minutes, all at 240° F.

By varying the time factor and keeping the process temperature the same, but one variable element entered into the experiment. In selecting the time factors, 45 minutes was taken because it was thought with good reason that this length of time was entirely too short and would give a basis for comparison. Sixty minutes was thought to be just a little under normal; 75 minutes was thought sufficient, and 90 minutes too long. In short, there were selected two lengths of time thought to be too short, one too long, and one about normal. After processing, the cans were allowed to cool naturally.

Method of examination. In examining the cans of salmon, an attempt was made to isolate all the types and species of organisms found to be present, and learn their relation to the bacteria originally inoculated in the cans. It should be kept in mind that some bacteria were in the salmon from the start. The scheme adopted is the one worked out by Dr. Weinzirl, of the University of Washington, and

was used in every case. Organisms looked for included anaerobes, aerobes, and thermophiles. The anaerobes and thermophiles were not fully identified, there being no positive way of determining their identity. Aerobes were fully identified.

The standard method followed consisted of obtaining these cultures from the fish in each can, i. e., two petri plates were cultured from the meat, one petri plate from the juice, a mass culture from the meat, and an anaerobic glucose agar culture from the meat. The petri plates were incubated at 37° C. The mass culture was incubated at 37° C. and 55° C. This method would favor the growth of bacteria whose optimum temperature is 37° and of thermophiles whose optimum temperature is 55° C. The anaerobic culture (glucose agar) would favor the growth of anaerobic bacteria whose optimum temperatures are 37° and 55° C. The glucose agar was boiled previously to expel any air which might be in the tube.

All mass culture bottles, petri dishes, test tubes, spoons, and can openers were thoroughly washed with soap and water, dried, and sterilized. The can was thoroughly washed and dried, and the top held over a gas flame to kill any bacteria remaining. The can was then opened with the sterile can opener, using due care not to contaminate the contents. After the can was opened the top layers of meat were removed with the sterile spoon; this portion of the meat having been heated, the bacteria would likely be killed. A mass culture was taken from the center meat, consisting of about four grams of meat, which was placed in a small, wide-mouthed bottle containing beef broth. The juice culture was taken with a spoon, which measured about four cubic centimeters, placed in a petri dish and later covered with melted agar. The two meat cultures were placed in a tube, thoroughly ground up with a small sterile pestle, and placed in petri dishes. These cultures were also covered with melted agar. The anaerobic culture was placed in a test tube and mixed with glucose agar. All these cultures were then incubated at 37° C. for from three to five days. The mass and anaerobic cultures were later removed and incubated at 55° to detect thermophiles.

The media for identification were potato, lactose fermentation tube, glucose fermentation tube, plain milk, litmus milk, and gelatine.

Incubation. The cans examined were all incubated at room temperature from 5 to 26 days. In no case was any swell or leaky can noticed. With the first lots of cans the shortest process was examined first, while with the second lot the longest process was examined first. The cans, as stated above, were heated or exhausted at 212° F.

for 15 minutes to secure the expulsion of air, thus forming a sterile vacuum. This is the general rule followed in most canneries.

Organisms recovered. Bacteria isolated from the cans were of three types, aerobes, anaerobes, and thermophiles, their frequency being in the order named. The thermophiles found seemed to be all of the same type and no further identification was made of them. Anaerobes were detected but not identified. Having such a large group of aerobes, it was necessary to separate them into types before they could be finally identified, and this was done by subculturing upon potato. By this method many like, or apparently like, organisms separated. Those encountered the greatest number of times were distinguished by the following characteristics: *B. subtilis* (Ehrenberg), an abundant, beady growth upon potato, turning pink after about the first 24 hours, when incubated at 37° C.; *B. vulgatus* (Flugge), large, hanging folds, grayish white in color when incubated at 37° for 24 hours; and *B. mesentericus* (Flugge), a light buff, finely wrinkled growth when incubated at 37° from 24 hours to three days. Many organisms found had not been inoculated in the cans, and therefore must have been in the raw fish or cans used in the experiment. The following foreign organisms were recovered from the cans after processing, some of which were isolated from a single colony found on a petri plate:

FOREIGN ORGANISMS RECOVERED

Name.	No. of cans in which found.
Thermophiles	12
Anaerobes	5
B. vulgatus	49
B. mesentericus	17
Sarcina	14
B. albolactus	12
B. subtilis	8
B. cereus	11
Micrococci	9
Strept. alba	1
B. alcaligines	1
B. ruminatus	1

Of the ten organisms inoculated into the salmon four were recovered from eight different cans after processing. These bacteria are given in the following table, with the length of time the can was processed:

INTRODUCED ORGANISMS RECOVERED

No. of cans in which found.	Name	Minutes processed.
1	B. albolactus	45
1	B. vulgatus	45
1	B. megatherium (soil)	45
1	B. subtilis (soil)	60
2	B. albolactus (soil)	75
1	B. vulgatus	90
1	B. albolactis (soil)	90

Sterility. A can of salmon examined in this experiment was determined to be sterile when the meat and juice cultures incubated in the petri dish produced less than three colonies of any one bacterium, when a spreader was present which was the result of less than three colonies, when the mass culture showed sterility, and when no gas was produced in the anaerobic culture tube. In the case of the meat and juice petri plate cultures, the one or two colonies found at times may have been caused by an error in the technique, unsterile media, or an organism may have fallen into the plate. Thus judgment was somewhat reserved. The following table gives the results of the experimental pack:

NON-STERILE CANS IN EXPERIMENTAL PACK

Time processed.	April 8		May 13		Total number non-sterile.	Percentage.
	Number of cans.	Number non-sterile.	Number of cans.	Number non-sterile.		
45 min..	10	10	12	7	17	77
60 min..	10	4	12	1	5	22
75 min..	10	1	12	2	3	14
90 min..	10	0	12	2	2	9

From the above it appears that about 77 per cent of the 45-minute process were non-sterile, 22 per cent of the 60-minute process, 14 per cent of the 75-minute process, and 9 per cent of the 90-minute process. These results compare favorably with the results obtained in the National Canners' laboratory at Seattle. It should be remembered that this experimental pack was put up under the same conditions that prevail in the average salmon cannery. The fish used were somewhat older than those usually canned in a commercial plant, giving more chance for bacterial infection.

CONCLUSIONS

1. But four of the original bacteria inoculated into the cans were recovered.

2. The process time, according to this experiment, for one-half pound flat cans of salmon should be between 75 and 90 minutes at 240° F.

Discussion.

Dr. E. E. Prince, Ottawa, Canada: This paper interests practical men because, when it is printed they will get the facts as to the time and temperature at which to process fish products for the market. In Canada we have done a good deal of work on the canned lobster, especially on what is called the blackening of lobsters. You open a can of lobsters and observe a very bad color, a black appearance with sometimes a bluish cast which is not very presentable at the table. But the lobster itself may not be really harmful as a food. It is merely a case of a bacterium which spoils the appearance and, of course, from a market point of view that is extremely important. From the food point of view it is less important. All bacteria are not the same. It is a very important matter for the bacteriologist to study minutely the various kinds of bacteria. From this paper we learn that thirteen different kinds of bacteria were found in canned salmon, yet I think we can lay it down as a general proposition that very rarely is canned salmon dangerous as food. All fish, of course, contain bacteria, and when the cans are filled and processed, these may or may not be killed. As a rule they are killed. This paper shows that only four survived even the comparatively low temperatures to which the author submitted them.

In Canada Professor F. C. Harrison investigated blackened lobsters last summer, and he found not thirteen, but I think about twenty-three, different bacteria in them. A person studying bacteria wants to know what the bacteria really do from a food point of view.

Many present here will have been asked—I am sure the question has been asked hundreds of times by various people—what effect parasites have upon the fish. In other words, when you find parasites in the flesh, skin, stomach, or intestines of a fish, is that fish fit for food?. On the whole, I would say that no fish parasites are injurious to human beings. Every parasite as a rule, has two hosts. The first host may be a bird, but the second host is not a human being. If you find a parasite in fish its second host is in some of the lower animals, frequently invertebrates, but not a human being. In Italy some fish parasites are cooked by the Italians for food.

PUBLIC AQUARIUMS

By Ward T. Bower

Bureau of Fisheries, Washington, D. C.

For purposes of education and recreation too much cannot be said in behalf of public aquariums. As proof of this, one has but to observe the eager and interested faces of the multitudes of visitors at our all-too-few institutions of this character. Irrespective of age or station in life, whether savant on the one extreme or school child on the other, there exists a common and spell-binding interest in marine creatures properly displayed. Here lie unbounded educational opportunities for the student of biology as well as for the most casual pleasure-seeker. Unfortunately but few municipalities have thus far recognized the great possibilities in this field. The public aquariums at New York, Philadelphia, Detroit, Miami, Boston, and Washington should point the way to many other cities. The next large city to be favored in this regard is San Francisco, where through private benefaction funds have already been provided and plans about completed for the erection of a splendid public aquarium to be located in Golden Gate Park and operated at municipal expense under the immediate supervision of the California Academy of Sciences.

Public aquariums are of comparatively modern origin. It was in the late sixties that an Englishman aroused an interest which soon caused various European cities, including London, Berlin, Paris, Hamburg, Hanover, Amsterdam, Brighton, and a little later Naples, to vie one with another in an effort to establish public aquariums. There were others, too, supported both by public and private enterprise. Today probably the most famous and finest of all aquariums is that at Naples.

In the earlier days of public aquariums it was deemed most appropriate to construct them so as to produce marine-like impressions upon the visitor. Thus, cavernous and subterranean entrances and grotto-like galleries and passageways were much in vogue. In some instances this semblance was worked out very well, but ordinarily it was at the sacrifice of features which we recognize as of far greater importance, including lighting, ventilation, temperature regulation, the comfort of the public, and other considerations affecting both the economical and advantageous display of fishes and other marine forms. These modern features are of special importance and can be

overlooked in no instance in the construction or operation of an aquarium.

The ideal public aquarium should be equipped for the display of both salt and fresh water specimens. There should also be operated as an adjunct a model fish hatchery where the public may see the hatching and rearing of several species of fish such as shad, white-fish, pike perch, yellow perch, and other semi-buoyant eggs incubated in jars, and the non-buoyant eggs of salmon and trout hatched on trays in troughs. A valuable feature also in connection with a modern aquarium is a public lecture hall, where popular talks may be given by the director or members of the staff. A museum with certain preserved aquatic specimens is also advisable. And still again, the maintenance of balanced or self-sustaining aquariums adds another excellent feature for nature study in connection with school work.

In maintaining displays of salt water fishes it is essential to have sea water. The experience of the Government with the aquarium at Washington and at several expositions clearly demonstrates this. Theoretically, sea water can be made of 81 parts of common salt, 7 parts of magnesium sulphate, 2 parts of chloride of potassium, and 10 parts of magnesium chloride, one pound making about three gallons. But fish do not thrive in it. Sea water, however, may be brought to the aquarium in tank cars and stored in reservoirs. It should be carefully filtered and may be used over and over again in a closed circulation. There should be one reservoir in reserve so that the water may "rest," or recuperate, as it were. It should be filtered each time before use. All water whether fresh or salt should be regularly filtered in public aquariums. Impurities which may be deleterious to fish life are thus removed and turbidity affecting clear display is avoided.

Since cleanliness is of prime importance, each aquarium should be cleaned on alternate days. On the days when not cleaned, feeding should occur. This plan has been adopted after many years of experimentation at Washington. One exception is the case of aquariums containing sea horses. These interesting fishes feed chiefly on Gammarus, which small form of life does not reproduce rapidly if the aquarium is disturbed frequently.

The food of fishes, reptiles, and aquatic mammals in captivity usually consists of chopped meat, clams, mussels, shrimps and small fish. It is essential in feeding not to be too generous; overfeeding is far worse than underfeeding. Surplus food should not be allowed to foul the bottom.

Temperature rules must be carefully observed. Tropical salt

water fishes, which make such a splendid showing, should be kept at about 70° to 75° F., while trout and kindred varieties do best at 45° to 55° F. This requires warming the water in the winter and refrigerating it in the summer.

Aquatic plants are not only essential in aquariums but they improve the scenic effect. Fish throw off carbonic gas and plants absorb it. Among the aquatic plants best suited to fresh water aquariums are *Cabomba, Potamogeton,* dwarf *Sagittaria, Anacharis,* and *Myriophyllum.* Some species of the last named probably are preferable. For salt water aquariums Irish moss, red and green algæ and sea lettuce are excellent aquatic plants; some aquariists consider the latter the best.

Fishes suffer from maladies, both parasitic and non-parasitic. If they become infected with parasites, either internal or external, it is advisable to do away with them or at least segregate the infected ones for observation and treatment, though there is really not much that can be done for them. In the case of non-parasitic troubles, salt water baths have been found very beneficial, the solution in which the fish are temporarily immersed being quite strong. This treatment is considered a specific for vegetable growth or fungus caused by frequent or careless handling.

In displaying fishes care must be taken to see that only compatible species and sizes are kept in one container. For example, in a salt water aquarium it is not safe to put certain other species with angel fish, for the latter are likely to destroy them. Likewise it is folly to put bass and trout together, even though temperatures permitted. Most of the fishes ordinarily displayed are cannibalistic. Thus, trout in an aquarium must be of about equal size to avoid loss from this cause.

Among the salt water fishes which are most interesting to the public may be mentioned the parrot fish, angel fish, squirrel fish, grouper, hind, sea horse, and yellowtail. Pleasing displays of fresh water fishes may be made of such species as salmon, trout, catfish, pike perch, bass, sunfish, muskellunge, goldfish, tench, dace, albino trout, bream, crappie, strawberry bass, whitefish—though hard to keep—ling cod, and eels. Turtles make a most interesting display; frogs also may be shown. Among the salamanders, newts, mud puppies, and hellbenders are of interest and are hardy. Clams and other mollusks are valuable in aquatic displays, but hard to keep.

A pool or grotto containing seals or large fish is also most interesting and instructive in a public aquarium. Fur seals would be of greatest interest, but they are more difficult to secure and to keep

than ordinary harbor or hair seals. There are now no fur seals alive in captivity. The last pair died in September, 1918, at the aquarium of the Bureau of Fisheries in Washington. They had survived about nine years.

Collections of specimens must be made from time to time to keep public aquariums properly stocked. Some are made locally and others at distant points. Exchanges may be made occasionally with other aquariums with mutual advantage, though to date this plan has not been adopted to any extent. The personal equation enters into this practice more or less, depending mainly on the acquaintance of the director of an aquarium with officials of similar institutions and Government or State officials. Arrangements may usually be made with the Bureau of Fisheries for shipments of specimens, also for supplies of eggs for incubation in the small hatchery which should be a part of every public aquarium. State fish commissions may also cooperate.

Specimens secured at a distance require great care in transportation, as fish are especially tender soon after capture. Specimens from 4 to 12 inches in length can be successfully transported in ordinary 10-gallon cans and larger fishes in larger receptacles. They must be kept at the proper temperature, and the water treated frequently either by lifting in a dipper and allowing to fall back slowly, or by forcing in compressed air through porous wood plugs in hard-rubber or metal liberators, as is done on the fish cars of the Federal and State fishery organizations. A special car is advisable for transporting specimens, though a small number of cans may be taken, by permission, in a regular baggage car. An attendant should accompany such shipments. Best of all, secure the use temporarily of a State or Government fish car for the transportation of valuable specimens any distance, such as, for example, from the Hudson River to Detroit. Tropical or semi-tropical salt-water specimens are secured chiefly at Key West, Fla., or the Bermudas. They are shipped in tanks on the inclosed decks of vessels, where proper temperature can be secured, the port of entry usually being New York.

Specimens for display purposes may be purchased from fishermen, also from a few private breeders of trout, bass, goldfish, bream, sunfish, crappie, etc., in this country. Under ordinary circumstances good supplies of fish for exhibition, and the smaller common species to be fed to the others, may be secured locally by a collector regularly attached to the aquarium staff.

Ordinarily, deep aquariums are better than shallow ones, as depth adds to the scenic effect, particularly if the lights and shadows are

made to appear in proper relationship. This tends to remove the effect of artificiality, especially if rocks, shells, and similar objects are judiciously placed. It makes the display more closely resemble natural surroundings and undoubtedly results in healthier fish.

In displaying fishes it has been found that there is less refraction of light to annoy the visitor if the back wall, with its covering of rocks, is set at an angle of about 45 degrees. The bottom should contain small gravel, or coarse white or gray sand. The introduction of compressed air in each aquarium is of great value in keeping the water fresh, especially if stored water is used.

The surface of the water should be at least one-half inch above the upper edge of the frame in front of the aquarium so there will be no refraction of light. A very important feature is the proper lighting of an aquarium. In most places it is necessary to provide artificial illumination; a shaded electric light suspended a short distance above the center of each tank usually suffices. Care should be exercised to deflect the light rays from the line of vision.

Different sizes of aquariums may be used for various species of fish, but ordinarily those about 5 feet in length, 4 feet in depth, and 3 feet wide at the bottom increasing to 5 feet at the top are most satisfactory. Aquariums with sloping rear walls are generally most desirable, thus affording a close view of the fish as they approach the bottom. Smaller aquariums, however, are generally made with perpendicular sides all around.

Transparent labels giving the name, both common and scientific, of specimens in each aquarium should be posted conveniently for the visitor. The labels should also briefly describe their habits, range, and any particularly interesting features.

CONCLUSION

A public aquarium in a city may speedily become one of its most popular and useful institutions. As compared with other public enterprises, it can be constructed at moderate cost, while the upkeep is not particularly great, especially if it is operated in conjunction with parks or other municipal institutions.

Of course these notes and suggestions do not pretend to include a complete description of methods and appliances, but are offered rather as a basis for discussion and to emphasize the importance of public aquariums as an educational influence leading ultimately to far greater appreciation and utilization of the enormous resources of the sea. It is hoped that there may be deeply impressed upon all the thought that a public aquarium is or should be a vivid presentation

of many forms and phases of water life, attractively staged and properly equipped for practical and scientific demonstration, thus transforming as by magic an irksome schoolroom study into a subject of absorbing interest, fascinating alike to teacher and pupil; and that an aquarium therefore does not or should not function solely as a pleasing and popular exhibit, but rather as an educational institution, a school of fishery economics affording exceptional facilities and advantages for the study of water life and the solution of water problems along the lines of sane and practical conservation.

Discussion.

MR. BOWER: It occurs to me that the Society may very properly endorse and advocate the more general maintenance of aquariums, public and private, than is now the case. For example, we may consider the City of Allentown, where we are now assembled. Here is a splendid civic community but with nothing in the way of a public aquarium. I am sure that such an institution would attract hundreds of thousands of visitors every year. In this connection I wish to mention the new public aquarium to be built in beautiful Golden Gate Park in San Francisco. About three or four years ago the late Mr. Ignatz Steinhart made a bequest of $250,000 for a public aquarium as a memorial to be known as the Steinhart Aquarium, provided the city would furnish funds for its operation. As a result San Francisco is going to have an aquarium that will probably surpass any other in the world. Dr. Barton W. Evermann, Director of the California Academy of Sciences, and a noted ichthyologist, is now completing plans for this splendid new institution. He has visited various aquariums in this country and has endeavored to take advantage of the best ideas in each. Let us hope that other cities may be similarly favored in the near future.

MR. JOHN P. WOODS, St. Louis, Mo.: Very modestly Mr. Bower has referred to the importance of the subject. I do not know of any city attraction that affords more interest than does an aquarium. I remember that at the opening of the Boston Aquarium in 1913 it was almost impossible to get in on account of the crowd. Almost every human being is interested in fish in some way. People like to catch, eat and look at them, and I do not know of any form of wild animal life that affords more real entertainment to the public than fish as they appear in an aquarium. I have a very strong admiration for fish, and my contact with people shows that they are practically all of the same mind. I support heartily the recommendation as to the desirability and value of public aquariums, and I hope that good Samaritans of wealth may, as in San Francisco, favor other cities which will realize the full value of the aquariums when they are acquired.

MR. ARTHUR L. MILLETT, Boston, Mass.: At the State Fair in the City of Springfield, near the center of Massachusetts, one section of a building is devoted to fisheries and game, and there we have an annual exhibition. The interest shown is remarkable, as people crowd into the building to see the fish displayed. It truly has been of great benefit not only to the people but to the Division of Fisheries and Game of our State. It helps

the whole cause all the way through. We also furnish similar exhibits for many of the fairs throughout the State in the fall of the year. We also are very proud of having the Boston Fish Pier, which is probably the biggest fresh fish wharf in this country. About 123,000,000 pounds are landed there annually. The Boston fish merchants are alive to the value of an aquarium and this year have prepared plans to have an aquarium and allied fisheries exhibit in one of the buildings. The room will be about 150 feet long and there will be an exhibition of various fishes in their native element and a display of fishing apparatus, marine curios, photographs, and other interesting objects. Also motion picture films will be shown to give the people an idea of actual methods of fishing. This is to be put in operation next year.

Mr. G. C. Leach, Washington, D. C.: The subject of aquariums has never been brought up before at meetings of the Society, and I believe the fish commissioners and fish culturists present must recognize the importance of public aquariums. It is incumbent upon us to educate the people of the country in regard to fish culture, and one of the best means of doing this is to bring before them proper displays of aquatic life. If you have public aquariums located in your city you will find school teachers very glad to cooperate by bringing in school children to study the fish life. If you interest the school children and educate them along the right lines you are doing much to develop and produce citizens of the best type and who will have a keen interest in and a better understanding of all forms of wild life.

Public aquariums hold great interest for visitors to cities and are always thronged. Dr. C. H. Townsend, Director of the Battery Park Aquarium, has stated that the institution attracts more people than any other public enterprise in the city of New York. Ever since the time of Jonah people have been interested in big fish; they like to hear big fish stories; they like to see big fish; they like to get acquainted with them. I think if the fish commissioners of this country want to do something of a really constructive nature for the good of the entire people they will get behind a movement to establish public aquariums in the various cities.

Mr. Carlos Avery, St. Paul, Minn.: As an illustration of the interest taken in an aquarium by the public, I want to call attention to the small exhibit we have at the State Fair in Minnesota, which is the largest fair of its kind in the world. Over 400,000 people visit it in one week, and the attendance at the aquarium is far greater than at any other place there except the immense grand stand which is especially for entertainment. We do not know how many people pass through the aquarium, but there is a continuous moving mass; they simply fight to get in to see the fish.

Mr. M. G. Sellers, Philadelphia, Pa.: In Philadelphia we tried to have a public aquarium, but could not get the municipal government interested. The Pennsylvania State Fish and Game Protective Association finally discovered that there was an opportunity to procure the old Fairmount pumping station for that purpose, and be it said to the credit of the anglers that they arranged the original subscriptions which started the institution.

Mr. B. O. Webster, Madison, Wis.: What we consider as a very fine aquarium is operated at the State fair at Milwaukee. The Conservation

Commission stocks it with fish and it is undoubtedly one of the strongest attractions at the fair. Contrary to the usual construction of an aquarium, it is built so that the fish may be seen from the outside. By merely passing around the outside of the building it is possible for the people to see all of the fish that are on exhibition. This idea applied to a State fair, or other similar place, where it could be used, is decidedly novel. Any work to be done on the aquarium can be accomplished from the inside without interference with or by the people who are looking at the exhibit from the outside.

MR. CARL KRAIKER, Philadelphia, Pa.: The Fairmount Park Commission expects to have its aquarial display completed by Thanksgiving Day. We have one room now that has been open to the public for four years; the second room, which is 200 feet long and 60 feet wide, has not been completed. We have a fair exhibit of both fresh and salt-water fishes. When completed we shall have about 90 tanks, the smallest of 60 gallons capacity, and the largest, 20,000 gallons. All of the tanks are of solid concrete with plate glass windows in front. The salt water is used over and over again, and care is taken that its saline quality is not lowered.

The aquarium in Fairmount Park is very well attended by the public in general, also by students from the university, colleges, high schools, and the lower grades down to the kindergarten classes. From time to time they hear talks and lectures in regard to fishes. The teachers say that it is very impressive to the children. On Thanksgiving Day, 1915, over 12,000 people were in attendance.

MR. N. R. BULLER, Harrisburg, Pa.: The question of public aquariums is one that should receive the hearty endorsement of this Society. We have always believed that there is nothing more educational than an exhibit of live fishes, and the Department of Fisheries of Pennsylvania has endeavored to devote certain portions of its hatchery buildings to the exhibition of fishes for educational purposes. Thousands of school children in the northwestern part of the State visit the aquarium at the Erie hatchery during the school term for the purpose of studying fish life. Even at the hatcheries isolated from centers of population, it is interesting to note how far people from the country will drive to see such an exhibit. At the Pleasant Mount hatchery, there is an entire room devoted to an aquarial display. I recently saw around the hatchery grounds a hundred automobiles belonging to people that had come in from the country districts to see the display of live fish. I think it is of great importance that the Society endorse the project of public aquariums.

MR. L. H. DARWIN, Seattle, Wash.: The exhibit that we have at Seattle has been of great value to thousands of people who throng it almost every day during the summer season. The attendance is not as large during the winter, but probably at least 1,000 people are there every day in the summer. We maintain chiefly fresh-water fish of mature age, so-called game fishes. The value of live fish as a drawing card was demonstrated to such an extent that we had to install a permanent aquarium at the State fair at North Yakima. A peculiarity there was that other exhibitors complained because the aquarium attracted more attention than any other exhibit, and they insisted that it be put in an out-of-the-way place. After eight years' experience I am able to testify that a public

aquarium is a splendid educational feature. Among other things I have observed doctors who paid daily visits to the aquarium for a long period of time trying to observe the diseases, if any, which manifest themselves in fishes.

MR. E. LEE LE COMPTE, Baltimore, Md.: In Maryland there are no large public aquariums, but we have small aquariums in the parks, and along some of our driveways, also at the Washington Monument and in Druid Hill Park in the city of Baltimore. The fish are placed in these aquariums as early in the spring as possible and removed late in the fall. Arrangements have been made with the Park Board to establish a large aquarium in Broening Park, which we are to keep stocked with fish. It is near salt water so that we shall have little trouble in displaying both fresh and salt water game and commercial fishes.

MR. W. G. BELL, Baltimore, Md.: In connection with the Poultry Show, held at the Fifth Regiment Armory in Baltimore, the Conservation Commission was requested to make a fish exhibit. This was done, and was the first of its kind ever held in the State of Maryland. Numerous local and foreign species were shown in the aquarium as well as methods of hatching eggs in troughs and jars. The deep interest displayed by many thousands who visited this exhibit was most gratifying and numerous requests have reached the Commission to establish a permanent exhibit in Druid Hill, our largest and most attractive park, so as to give the public practical knowledge of fish-cultural work conducted in the State of Maryland.

POLLUTION OF STREAMS

A General Discussion

Mr. N. R. Buller, Harrisburg, Pa.: Stream pollution is a matter of great importance to every person interested in the conservation of fish. On account of great industrial activities and mining operations the streams of Pennsylvania are, perhaps, in worse condition than those of any other State. This is one of the greatest questions confronting the State today, both in regard to the welfare of the fish and the health of the people. The manufacturing interests and the railroads admit that it is a question involving a great deal and one that is extremely difficult of solution. The State Department of Health has jurisdiction over pollution, in so far as the sewage of cities is concerned; but the laws exempt the drainage from mines, tanneries, and other industrial establishments. The Department of Fisheries has under its authority the mining and industrial waste, but the laws are inadequate. Our law as it stands today prohibits anyone from emptying into the streams any deleterious substance. Unfortunately the fine for violation is only $100, which does not meet the situation. The courts have never sustained the Commonwealth in any prosecutions of mine operators. They always refer to a famous decision given in the early days of mining, known as the case of Sanderson vs. the Commonwealth of Pennsylvania. That decision held that the owners had the right to flow mine waste into a stream, as there was no other place for it to flow. Mine waste is probably more poisonous to the streams than any other waste we have. Without better laws it will be a long time before much can be accomplished regarding purification of streams. As long as sewage from cities is allowed to flow into the streams, the flowage into the same waters of acids which neutralize or kill the germs is the only thing that prevents serious epidemics. A suit is pending between the Pennsylvania Railroad Company and the Mellon interests, the result of which is awaited with much interest. The railroad has a $25,000,000 water project in jeopardy in case the Mellons open up the mines at its head. While the legislature has authorized the Department of Fisheries to employ 65 men in this branch of the service, it has never yet appropriated more than sufficient money for nine men, who naturally cannot accomplish a great deal. This entire question can never be settled unless there is better legislation and concerted action by the people interested. It must be threshed out through cooperation and education.

Mr. M. L. Alexander, New Orleans, La.: This is one of the most important questions pertaining to our fisheries. In the summer of 1921 Mr. Hoover called a conference at Washington to consider two questions, stream pollution and control of migratory fish. He invited the commissioners and representatives of the Atlantic Coast and Gulf States, possibly 100 of whom were in attendance, and the matter was gone into very exhaustively. Resolutions were adopted and the final conclusion of the conference was that the question of stream pollution should be properly controlled by the Federal Government, largely for the reason that such pollution is not only brought about by the industries located along the inland streams but,

in large measure, by the oil burning and oil carrying vessels plying along the coast or going to foreign ports. As a large percentage of these vessels are carrying foreign flags, it was a question not only of national but of international importance. It might be appropriate for this Society to endorse the action of the Hoover conference, and for the commissioners to urge their Senators and Representatives to push through Congress some law sufficiently drastic to meet this particular condition. I believe that is the only way to get the desired results.

MR. W. E. BARBER, Madison, Wis.: Wisconsin is a manufacturing State. Along the Fox and Wisconsin River valleys there are about 60 paper mills, together with other industrial plants in the different cities located on those streams. I do not know how the Federal Government is going to step into Wisconsin and tell the people there how to control the industrial waste from the plants along those streams, as they are inland waters. I am opposed to a centralized government at Washington coming into our State and telling us what we are to do with our local institutions. The question of the pollution of streams has been discussed for years at meetings of this Society and perhaps some progress has been made. We have accomplished something in Wisconsin, but it is a discouraging job. The cities located along the streams welcomed every manufacturing plant they could get; they offered every inducement to locate in their communities and employ their labor, and the plants were built without any attention whatever to disposition of the waste. The paper mill waste is enormous, but it can be controlled. The question is how to do it. We have visited every paper mill in our State; we have been to the pea-canning plants and have laid plans before many of them. Some have cooperated and gone ahead with certain improvements, but the great bulk of the waste matter is still flowing into the streams, destroying fish life and polluting the waters, making them unfit for domestic use.

The only way to settle this is for the States to enact stringent legislation providing a heavy penalty for violation of that law, giving these institutions sufficient time to regulate their plants to take care of the waste, and then enforce the law. Do you suppose that if it were known to the paper mills of this country that they could make $50,000 by putting in a machine costing $25,000 they would not do it? We all know that as a business proposition they would accept and go ahead with any improvement necessary to make their institution a better one; but when it comes to a matter of this sort, where the interests of the great mass of the people are concerned, the institutions pay no attention until confronted with a real law and prosecution thereunder. The Wisconsin Traction, Heat, Light and Power Company, of Milwaukee, has a gas plant located at Appleton. They were going to take out one of their old tanks which had been in use 40 years and never emptied. It held thousands of gallons and was practically full of sediment and tar accumulations from the manufacture of gas. They pumped one-half the contents into Fox River and it was not long until the odor spread all over Appleton and people began to wonder what was the matter. I went there immediately and looked over the situation. It was stopped, of course, and the company hauled away the balance of the contents of the tank as they should have done with all of it. We prosecuted these people, but our maximum fine for such offenses is $100 and the

company simply went into court, paid the fine, and there the matter ended. We want to be fair and square with all the manufacturing interests. We should not say that within 60 or 90 days, or anything less than a year certain improvements must be made. We should give them sufficient time. Then there should be a law with a penalty of from $2,000 to $5,000 for the second offense, and there is no doubt that improvements would be made and our streams cleaned up.

Mr. Hoover's meeting was a fine thing. International waters, of course, and outlying waters along the coast are for the Government to take care of; but I object to the United States Government coming into our State and telling us what we must do with our streams and other waters. Our legislature convenes once in two years, and our commission will recommend a law along the line I have outlined, giving manufacturing plants sufficient time to take care of their industrial waste. Then we should fix a penalty that will make them sit up and take notice. I would deal fairly with them, but in that way we would clean up the streams. I believe our legislature is in the right temper to pass such a law. The protests we get on account of this sort of thing are mighty annoying, when we are tied hand and foot with a maximum fine of $100!

Mr. Alexander: I do not think Mr. Hoover contemplated taking control within the States, particularly as to inland conditions. I am possibly as strong a believer in State rights as anyone here. That is the principle upon which our Government has largely been founded, as we see it down in my section of the country; but we have had some demonstrations of federal control. Take the yellow fever situation in the South, and particularly in my State; also the matter of levee protection along the Mississippi River, and the boll weevil in the cotton districts. All of these were taken care of by the Federal Government. Many of the rivers in Wisconsin which are affected by stream pollution probably enter into other States. These rivers go from State to State, and when that condition prevails it seems to me that the Federal Government could well come in and advise with you, and, if necessary, take control and remedy the condition, recognized by all as one of the most serious with which we have to contend.

Mr. E. Lee LeCompte, Baltimore, Md.: I beg to state that I cannot agree with Mr. Barber. Wisconsin cities may, though I doubt it, be located on streams different from other States of the union. As the Game Warden of Maryland, I have more trouble with pollution than with the enforcement of the game and fish laws—ten times as much. In many instances the pollution is not caused by the manufacturing industries located in our State. For instance there is one pulp mill in West Virginia just across the border, which pollutes the waters of the Potomac River. The mill had been putting all of its waste into the Potomac, and finally the people below at Cumberland complained that the fish life was absolutely destroyed. I am just as strong an advocate of State rights as any one here, but when the States do not take care of a situation of that kind, give me federal legislation that will. A justice of the peace thinks that a $25 fine for a violation of the game and fish laws is awful and that a man ought not to pay more than a dollar and a half at the outside. So how can you ever get a conviction with a fine of $2,000? I have had a number of pollution cases, but have never had one brought to trial, because I had no faith in the

justice of the peace fining a man even $100. I worked to get the manufacturing industries to cooperate. I do not want to put any manufacturing industry to extra expense or trouble, nor do I want them to close their plants, because our cities have invited the industries into their communities, offering free sites in many instances.

One of the pulp mills got an engineer and spent about $47,000 and the manager told me it was the best work they ever did. They put in a plant whereby waste was used for some by-product which they are selling. We received complaints from Thomas Creek on the Monocacy River, one of our great bass streams. A very fine dust from a stone quarry in Pennsylvania was allowed to go into the stream on which this manufacturing plant was located. That grit would stick to the gills or throat of the fish and cause death. Of course, the fish could not go through the water without getting the grit. I could not do anything as that manufacturing industry was in another State. Federal legislation could do something, but not State laws. We can pass all the laws we please in the State of Maryland, but some of these streams come from Pennsylvania and some from West Virginia, and under our State laws it is impossible to prosecute violators not located in our State. We would prefer to have Federal Legislation alone take care of the question of pollution.

Mr. Buller: At the last session of the legislature of Pennsylvania the Department of Fisheries carefully drafted a bill carrying a fine of $2,000 to enable it to better cope with this situation. This bill was widely advertised and public hearings were held, and I regret to say that at those hearings we received no cooperation from the public at large, the people who complained of the conditions. Every manufacturing interest of any importance and the mining interests were heard. In spite of their protests, the Department of Fisheries was able to get the bill out of the Committee on Fisheries to which it had been referred, and it passed the first reading in the House of Representatives. On the second reading it was referred to the Committee on Municipal Corporations and nothing further has been heard from it. I have failed to learn what interest that committee has in the pollution of streams. I hope Wisconsin will be more successful in getting this legislation than we were in Pennslyvania.

Mr. A. L. Millett, Boston, Mass.: Massachusetts has laws enough in regard to pollution but enforcement is well nigh impossible. The conference in Washington called by Secretary Hoover was intended to be a step forward, to improve if possible upon local handling of the matter. It was not the idea to take away State rights. I presented the case for Massachusetts at that hearing, and my stand was backed by the gentleman from Louisiana, which shows that we were pretty much in accord. Virginia, Maryland, South Carolina, and Georgia all did likewise. We discussed the subject in a great broad way. We on the coast are up against oil pollution by steamers. The waste dumped by those steamers comes into every port, so that today in the New York fish trade the designation "Standard Oil" is applied to certain kinds of lobsters and fish because they simply reek of petroleum. The meeting was an honest effort to do something with the pollution question. Whether Wisconsin or Massachusetts, there is no State in this country that can handle the pollution problem by itself. The question of State rights was very nicely gotten over by Mr. Hoover's splendid way

of handling the matter. He termed it federal aid to the States, help to the States in handling this great problem. He did it very nicely. He clearly showed a strong disposition to help. He said that it was very evident to him that the States could not handle this problem individually and he was willing to come in and assist.

Take the case of the Merrimac River. Probably quite a number of you are aware of what the Merrimac means to the cotton industry. For three miles there is nothing but factories along that river. We cannot put them out of business for the sake of the few fish that may come up some year, or five or ten years from now. The matter must be looked at in a broad light. Some rivers, where there are but few factories or other small interests, can be reclaimed, but on other rivers we have not much of a chance. We are all interested in fish, but we must look on both sides of the problem.

Mr. Carlos Avery, St. Paul, Minn.: The fact that Secretary Hoover, with his great influence and prestige, has taken an interest in this subject offers the first ray of hope in all the years I have heard this question discussed by this Society. The Secretary has recognized what we know to be the fact, that the pollution problem is far greater in the Atlantic Coast States than in our inland States. We do not know anything about pollution in the sense that the streams are poisoned in the east. Pennsylvania certainly has knowledge of it, and I think the situation exists practically throughout the country. States may pass laws, but, however stringent they may be, it is practically impossible to enforce them. Therefore, I hope that this Society will go on record as endorsing the movement of Secretary Hoover in the strongest possible way.

Mr. M. G. Sellers, Philadelphia, Pa.: The Federal Government exercises jurisdiction over streams with respect to navigation and I think it would be one great step in advance if we could induce Congress to exercise some power over streams on the question of pollution. I think we ought to admit, without further argument, that this job is too big for any State; it must be an interstate job, a federal job. I want to suggest that the American Bar Association undertake the preparation of a model statute on stream pollution which the individual States may adopt.

Mr. J. M. Crampton, New Haven, Conn.: No subject interests Connecticut more than pollution. This important question is being handled by a lot of lawyers in the legislative halls of our States. We see the results at home and we should clean house first. Norwich, Conn., is as well located for taking care of waste products as any city in the United States and if it would do so the Thames could be filled with fish. Where have our shad and black bass gone? We are not producing today 10 per cent of the fish we did. Take our oyster and shad industries and the fishing industries throughout the State, even the lobsters, and you will find they are all contaminated where they border the cities. This should not be. Commissioner Block of Connecticut says that at comparatively small expense each industry could do away with all of the pollution in our Naugatuck River where today it would take the hair off a mule's leg to wade across it. Unless this subject is taken hold of by the Federal Government you will never see any radical change.

Mr. Barber: I admire Mr. Hoover as much as does any man here. But the Federal Government cannot come in and tell us that we must clean

up the Wisconsin River and Fox River, because they are Wisconsin streams from source to mouth. Along the water sheds of those rivers there are at least 150 plants throwing their waste matter into them. If we go to those companies and say that they must stop polluting the streams, that the fine is from $2,500 to $5,000 they are going to clean house. There is no question about it. There are canneries in our State which are pouring the most putrid, putrescent nastiness that you can imagine into a stream with residences across the street. Can we expect Congress to go in there and do a job that is purely a State job? I am morally certain that our legislature will pass a law at the next session that will force those men to stop polluting the streams.

We want to cooperate with Mr. Hoover as to the Mississippi River, which is an interstate water. It is perfectly proper that the Federal Government should take hold of that stream, but these other streams are ours, and we are abundantly able to take care of them. We know of a lot of rivers that are boundary rivers, and I am sure that the States bordering on those rivers will help Mr. Hoover to clean them up. The people of our State and the States all over the Union are sick and tired of the conditions that have been imposed through pollution of streams of their respective States. If a resolution is offered here endorsing Mr. Hoover's plan, I shall vote for it, but I want also to vote for a resolution urging every State to clean up its own streams. I think it is up to us to clean up our respective States, and the way to do it is through stringent laws passed by our legislatures.

Mr. J. W. Titcomb, Albany, N. Y.: I want to refer to a phase of the question which has not been brought out in discussion, namely, the study of a basis or standard of pollution. In many places there is no question as to what pollution is. In New York there is a law against emptying into streams anything that kills fish but you have to prove it will kill fish, that they cannot live in the water. The minnow test heretofore employed consists of putting a catch of minnows into the alleged polluted water, and another catch into what is called pure water. Today the Empire State has an annual appropriation of $10,000 for the study of pollution problems. A chemist is making a gas analysis and a biologist a study of the forage of the streams and the foods of the fish. A new line of evidence in pollution has been established in the State through this study of what produces the food which feeds the fishes. Without the oxygen and the vegetation the fish cannot live, and the vegetation in the waters is the best food for the small fishes. The same kind of a study has to be made, to a certain extent, along our coasts, where the salt waters become polluted. We have found out the conditions under which the forage can be retained, this being the basis for all fish life.

I think the side of this question I am presenting is entirely new in this country; I do not know that it has been taken up before, but it appears to me that the information thus obtained is for the benefit of every citizen of the United States. The investigations in New York are being made in a small way and it will take years to work them out properly; they should be made under the direction of the United States Government, so as to have a basis or standard of pollution, in order to enforce the law. There is no question of the fact of pollution, but when the manufacturer is required to

take care of his by-products and his factory waste, he must be given some standard in the matter, and know what is permissible and what is not permissible. It seems to me that here again we have the argument that this work should be done by the Federal Government, assisted by the States.

Mr. Leach: I think that Mr. Barber has been misunderstood here, also that he has not fully understood what was said or what action was taken at the conference called by the Secretary of Commerce in Washington last June. The Secretary said that, as a servant of the people, he was there to aid the States in solving the problem in regard to trade waste, and that he was ready to receive any advice from the delegates as to how he could aid them. I think the Secretary will give the States the same square deal that Mr. Barber expects to give his manufacturers, and, in the end, everything will work out satisfactorily and Mr. Barber and the rest of the State Commissioners will be in favor of any sound and sensible trade waste law that may be enacted.

Mr. Barber: Has there been any effort to find out what industrial wastes are worth? The paper mills of our State were ordered to put in a screening process to take out the solid waste matter that they were depositing in the rivers. We recommended a machine known as the "Save-All," or some other process that would take out the pulp used in the manufacture of paper. Practically all the mills did something. The next year the superintendent of the largest plant in Wisconsin said he wished we had made him put in those machines ten years before, as he had made enough that year in the saving of the waste products to pay for all of the machines. A paper mill at Kaukauna has put in a machine for reclaiming the acids used in the manufacture of the paper, and they are using those acids over and over again. The rest of the mills do not put them in because they are not forced to do so.

Mr. Buller: The same condition exists in most of the paper mills in Pennsylvania. They are reclaiming valuable by-products since the agitation for cleaning up the streams has developed. There was a plant on Tulpehocken Creek, manufacturing manganese iron from Cuba. The wash from these ores was very poisonous, destroying all fish in the streams. The matter was taken up with them by the Department of Fisheries and they installed an electric precipitator eliminating the water entirely. It cost the company $30,000, but they are reclaiming a valuable by-product in the form of potash which is more than paying the expense of installation.

EFFECT OF DROUGHT AND EXTREME HEAT OF SUMMER ON FISH LIFE

Open Discussion

Mr. N. R. Buller, Harrisburg, Pa.: This is an open discussion as to the effect of the extended drought and extremely hot weather during this summer on fish life. This subject was brought to the attention of the Society on account of the extremely hot weather experienced this summer and the great and extended drought that has occurred in Pennsylvania. Never before to my recollection has the drought been so severe and the heat so intense. The effect has been very serious on various species of fish in our streams and even in our lakes. I personally observed a great many of our lakes during the month of August, particularly, when the vegetation of the bottoms should be green, and most of it was as brown as the brown moss on the hillsides, apparently dead. In numerous instances where the drought had seriously affected streams, the department received requests to remove the fish, but we were not able to do so because of no place to put them, that is, in close proximity to the original location, and it would not have been possible to carry them any great distance in hot weather.

The only remedy I can see is that all interested in this matter lend every possible effort to support forestry programs to the limit, because denuding the hills and reckless destroying of forests have brought about this condition. I believe we should do all we can to urge that the program for reforestation be carried out more rapidly than it is at present. Pennsylvania has many millions of acres of mountainous land not valuable for other than forestry purposes. As I understand it, the Forestry Commission is attempting the reforestation of these mountains on a very large scale, and we believe that if we again restore these forests our trout streams and other waters will not be so affected in times like the present.

Mr. Carlos Avery, St. Paul, Minn.: There is a condition prevailing in the Northwestern States, in the lake region, which is somewhat different from that experienced in Pennsylvania. The mortality of fishes in that region has been phenomenal this year. It is recurrent, however, in some lakes, and investigations made indicate that the causes which may and usually do produce the conditions, come every year. Some investigations made in a lake in Wisconsin by the United States Bureau of Fisheries and the University of Wisconsin, revealed that the mortality recurring annually in that lake is due to stagnation in the lower strata of the water.

We have lakes in Minnesota, about 300 square miles in area where there is great mortality of fish every year, windrows of them being piled up along the shores for several miles. This year it was worse than usual, no doubt on account of the great heat and protracted drought. The Bureau of Fisheries detailed a man from the Fairport Biological Station to assist our biologist in making an investigation, and after a cursory examination they came to the conclusion that the cause was probably the stagnation of the lower strata of water in the lake. They could find no other cause, and naturally assumed that was the reason, though the lake is not deep.

This year great quantities of valuable fish were lost in deep lakes where they had never died in that way before. The varieties affected chiefly were the whitefishes, the loss being extremely heavy on tullibee or mongrel whitefish, and there was some loss of pike perch; also in the Mille Lacs some of the pickerels and other varieties were lost, but chiefly the deep water fishes were affected. The men who made the investigation in Mille Lacs this year estimated that towards the close of the period of mortality there were at least 650,000 pounds of dead fish around the shores of the lake, which means that several million pounds of fish have died in that one lake this summer. Professor Riley, of our State University, formerly of Cornell, is studying the question to find out, if possible, whether any of this mortality is due to parasitical infection.

Mr. W. E. Barber, Madison, Wis.: Conditions in Wisconsin have not been as bad as in Minnesota, but we found that in our deep water lakes there was less mortality among the fishes than in the shallow lakes. In various sections of the State the fish were dying, and we did not know what was the cause. Professor Wagner, biologist at the University, made some very extensive investigations and stated that the excessive heat and lack of wind to aerate the water caused the death of the fishes.

The lake in Wisconsin referred to by Mr. Avery is Lake Monona, and pollution is the chief cause of its fish mortality. Sewage from Madison drains into it, and causes a tremendous growth of vegetation, also a heavy scum and green slime on the top of the water during the summer months; the stench is so bad as to cause complaint in almost every section when the wind comes from the direction of the lake. The city had to make better arrangements for the disposal of its sewage.

But I think there is no remedy for the loss of fish in the ordinary lake when we have extraordinary seasons of excessive heat, such as this summer. It always has occurred and always will occur, and the wonder of it is, when we realize the tremendous loss of fish through such conditions as we have had this summer and the heavy coating of ice and snow in the winter, that there are any fish left. Of course, these fish multiply rapidly and we have fish in most of our lakes notwithstanding these conditions.

Dr. E. E. Prince, Ottawa, Canada: Mr. Barber's statements are confirmed by what we have found in some lakes in Canada, very far from any settlements under perfectly virgin conditions. That is to say, the depth of the lake does not seem to have any relation to the serious loss of fish. I happened to be on a remote lake in Canada a year or two ago, a lake practically only visited by Indians and fur trappers, although there are some small settlements at the west end. It is a very shallow lake and covers 480 square miles. At times there is a tremendous destruction of fish. You find whitefish and yellow perch and various other fishes lying dead in windrows. It seems to be due to the unicellular alga (Tetragonium) which grows luxuriously in certain seasons and then decays, poisoning the water and creating an offensive odor. I mention this because Mr. Avery referred to the depth and stagnation as having had something to do with the death of the fish; but when you find lakes which are very shallow, like the Lesser Slave Lake, and distant from any population, it is perfectly clear that it is due to some cause such as I have mentioned.

Mr. E. Lee LeCompte, Baltimore, Md.: The conditions in Maryland

are very much like those in Pennsylvania. The pollution of streams by cities has been remedied by requiring all places with a population of 3,000 or over to put in disposal plants. This has been accomplished through the people interested in the oyster industry. The waste from the cities going into the streams was destroying the oysters, and as there are many people interested in the oyster industry, there was not much trouble in getting the disposal plants. I have seen water coming from the disposal plant at Back River in Baltimore, also in Cambridge and Easton, which the scientists claim is as pure as before it was so used. I have not tasted it, so cannot vouch for its sweetness.

The matter goes back to the question of deforestation. The country is denuded of the good timber, especially in the mountain sections, and there is no shade left for the small streams. Therefore with trout all over our State, there is no question that in a summer such as this past one there will be destruction of trout in the fresh water streams. The planting of willows along the streams for shade has been advised, and I think it a very good idea. They would grow there and be beneficial. I do not think we can do anything in our State unless it is through the Forestry Board.

Mr. Buller: I am very much interested in the matter of planting trees, and I urge upon all to render every possible assistance to the forestry departments, because without trees there cannot be fish. This past winter delegations from different sections of our State called at the department with reference to taking care of streams in which they were interested. A delegation of ladies from the neighboring county of Berks came and asked whether the Department of Fisheries would assist in reforestation along Maiden Creek. They got in touch with the Forestry Commissioner, and I was much pleased to learn later that they set out 50,000 trees on the banks of Maiden Creek this past summer and have made application for 30,000 for next season. I believe that every fishery association should endeavor to get the people to plant trees and shrubbery for a certain distance on each side of the streams on which they live. If that is done, in the course of a few years we shall have shaded streams, thus saving the fish in times of drought. No one who has not made a study of it can conceive the enormous evaporation from streams exposed to the sun.

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'08 ANTIPA, PROF. GREGOIRE, Inspector-General of Fisheries, Bucharest, Roumania.
'06 BESANA, GIUSEPPE, Lombardy Fisheries Society, Via Rugabello 19, Milan, Italy.
'09 BLUE RIDGE ROD AND GUN CLUB, Harper's Ferry, W. Va.
'93 BORODIN, NICOLAS, Petrograd, Russia.
'12 CALDERWOOD, W. L., Inspector of Salmon Fisheries for Scotland, Edinburgh, Scotland.
'04 DENBIGH, LORD, London, England.
'89 FISH PROTECTIVE ASSOCIATION OF EASTERN PENNSYLVANIA, 1020 Arch St., Philadelphia, Pa.
'06 GRIMM, DR. OSCAR, Petrograd, Russia.
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Patrons

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Libraries

'19 College of Fisheries, Univ. of Washington, Seattle, Wash.
'20 Harvard College, Cambridge, Mass.
'21 John Crerar Library, Chicago, Ill.
'20 Massachusetts Institute of Technology, Cambridge, Mass.
'18 New York Public Library, 476 Fifth Ave., New York, N. Y.
'18 New York State Library, Albany, N. Y.
'21 Scripps Institution for Biological Research, La Jolla, Calif.
'20 University of Indiana, Bloomington, Ind.
'20 University of Michigan, Ann Arbor, Mich.
'21 University of Nebraska, Lincoln, Nebr.
'21 University of Toronto, Toronto, Canada.
'20 Yale University, New Haven, Conn.

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'16 MARSCHALK, PAUL, Warroad, Minn.
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Recapitulation

Honorary	66
Corresponding	10
Patrons	53
Active (including 45 clubs, 12 libraries and 7 State organizations)	556
Total	685

CONSTITUTION

(As amended to date)

ARTICLE I

NAME AND OBJECT

The name of this Society shall be American Fisheries Society. Its object shall be to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; the uniting and encouraging of all interests of fish culture and the fisheries, and the treatment of all questions regarding fish, of a scientific and economic character.

ARTICLE II

MEMBERSHIP

Active Members.—Any person may, upon a two-thirds vote and the payment of three dollars, become a member of this Society. In case members do not pay their fees, which shall be three dollars per year after first year, and are delinquent for two years, they shall be notified by the treasurer, and if the amount due is not paid within a month thereafter, they shall be, without further notice, dropped from the roll of membership.

Any sporting or fishing club, society, firm, or corporation, upon two-thirds vote and the payment of an annual fee of five dollars, may become a member of this Society and be entitled to all its publications. Libraries shall be admitted to membership at three dollars a year.

Any state board or commission may, upon the payment of an annual fee of ten dollars, become a member of this Society and be entitled to all of its publications.

Life Members.—Any person shall, upon a two-thirds vote and the payment of twenty-five dollars, become a life member of this Society, and shall thereafter be exempt from all annual dues.

Patrons.—Any person, society, club, firm, or corporation, on approval by the Executive Committee and on payment of $50.00, may become a Patron of this Society with all the privileges of a life member, and then shall be listed as such in all published lists of the Society. The money thus received shall become part of the permanent funds of the Society and the interest alone be used as the Society shall designate.

Honorary and Corresponding Members.—Any person can be made an honorary or a corresponding member upon a two-thirds vote of the members present at any regular meeting.

The President (by name) of the United States and the Governors (by name) of the several States shall be honorary members of the Society.

Election of Members Between Annual Meetings.—The President, Recording Secretary, and Treasurer of the Society are hereby authorized, during the time intervening between annual meetings, to act on all individual applications for membership in the Society, a majority vote of the Committee to elect or reject such applications as may be duly made.

ARTICLE III

SECTIONS

On presentation of a formal written petition signed by one hundred or more members, the Executive Committee of the American Fisheries Society may approve the formation in any region of a Section of the American Fisheries Society to be known as the ——— Section.

Such a Section may organize by electing its own officers, and by adopting such rules as are not in conflict with the Constitution and By-Laws of the American Fisheries Society.

It may hold meetings and otherwise advance the general interests of the Society, except that the time and place of its annual meeting must receive the approval of the Executive Committee of the American Fisheries Society, and that without specific vote of the American Fisheries Society, the Section shall not commit itself to any expression of public policy on fishing matters.

It may further incur indebtedness to an amount necessary for the conduct of its work not to exceed one-half of the sum received in annual dues from members of said Section.

Such bills duly approved by the Chairman and Recorder of the Section shall be paid on presentation to the Treasurer of the American Fisheries Society.

ARTICLE IV

OFFICERS

The officers of this Society shall be a president and a vice-president, who shall be ineligible for election to the same office until a year after the expiration of their term; an executive secretary, a recording secretary, a treasurer, and an executive committee of seven,

which, with the officers before named, shall form a council and transact such business as may be necessary when the Society is not in session—four to constitute a quorum.

In addition to the officers above named there shall be elected annually five vice-presidents who shall be in charge of the following five divisions or sections:

1. Fish culture.
2. Commercial fishing.
3. Aquatic biology and physics.
4. Angling.
5. Protection and legislation.

Vice-presidents of sections may be called upon by the President to present reports of the work of their sections, or they may voluntarily present such reports when material of particular value can be offered by a given division.

ARTICLE V

MEETINGS

The regular meeting of the Society shall be held once a year, the time and place being decided upon at the previous meeting, or, in default of such action, by the executive committee.

ARTICLE VI

ORDER OF BUSINESS

1. Call to order by president.
2. Roll call of members.
3. Applications for membership.
4. Reports of officers.
    a. President.
    b. Secretary.
    c. Treasurer.
    d. Vice-presidents of Divisions.
    e. Standing Committees.
5. Committees appointed by the president.
    a. Committee of five on nomination of officers for ensuing year.
    b. Committee of three on time and place of next meeting.
    c. Auditing committee of three.
    d. Committee of three on program.
    e. Committee of three on publication.
    f. Committee of three on publicity.

6. Reading of papers and discussion of same.
   (Note—In the reading of papers preference shall be given to the members present.)
7. Miscellaneous business.
8. Adjournment.

ARTICLE VII

CHANGING THE CONSTITUTION

The Constitution of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least fifteen members are present at said regular meeting.